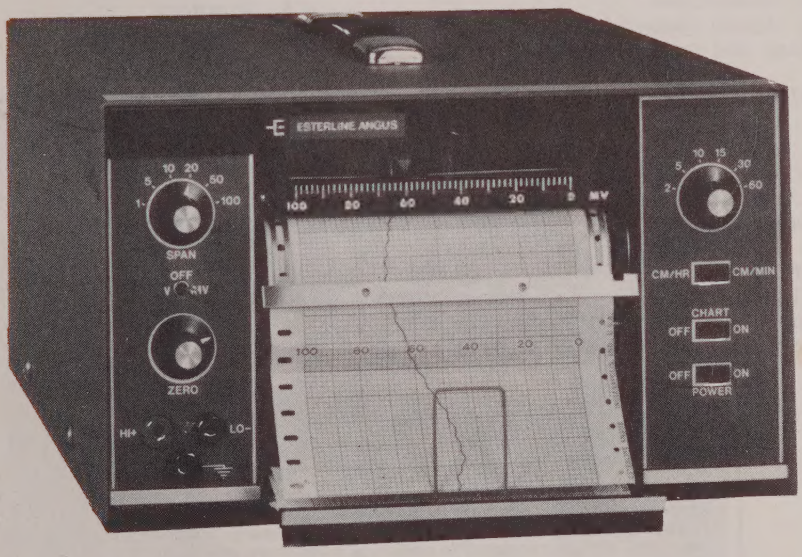
INSTRUCTION MANUAL

FOR MODEL MS411B STOCK

AC Miniservo®

STRIP-CHART RECORDER



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CONTENTS

SECTION 1 - INSTRUMENT DESCRIPTION

1.1 Introduction 1-1
1.2 Specifications 1-1
1.3 Theory of Operation. 1-2
1.3.1 Preamp 1-2
1.3.2 Servo Amp. 1-2
1.3.3 Chart Stepper Drive. 1-4

SECTION 2 - INSTALLATION

2.1 Unpacking Instructions 2-1
2.2 Instrument Mounting. 2-1
2.3 Installing Fuse. 2-2
2.4 Chart Installation 2-2
2.4.1 Charting Procedures. 2-2
2.5 Ink Cartridge Installation 2-3
2.5.1 Inking Procedures. 2-3
2.6 Electrical Connections 2-3
2.6.1 Analog Signal Connections. . . . 2-4
2.6.2 Shielding and Grounding. 2-4

SECTION 3 - OPERATION

3.1 General. 3-1
3.2 Operating Controls 3-1
3.2.1 Front Panel Controls 3-1
3.2.2 Rear Panel Controls. 3-2
3.3 Operation. 3-2
3.3.1 Zero Offset. 3-2
3.3.2 Zero Elevation 3-2
3.3.3 Zero Suppression 3-3
3.3.4 PIP Operation. 3-3

SECTION 4 - MAINTENANCE

4.1 General. 4-1
4.2 Inspection 4-1
4.3 Cleaning 4-1
4.4 Lubrication. 4-1
4.5 Calibration. 4-1
4.5.1 Test Equipment Required. 4-1
4.5.2 Precalibration Instructions. . . 4-2
4.5.3 Electrical Cal. Procedures . . . 4-2

4.6 Disassembly. 4-2
4.6.1 Cover Removal. 4-4
4.6.2 Inner Chassis Assy. Removal. . . 4-4
4.6.3 Preamp Module Removal. 4-5
4.6.4 Chart Drive Module Removal . . . 4-5
4.6.5 Servo Board Removal. 4-5
4.7 Drive Cable Replacement. 4-5
4.8 Shutdown 4-6
4.9 Troubleshooting. 4-6

SECTION 5 - PART LIST

5.1 Introduction 5-1
5.2 Parts Table. 5-1
5.3 Ordering Information 5-1

INDEX TO REPLACEMENT PARTS TABLE. . . . 5-1

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SECTION 1 - INSTRUMENT DESCRIPTION

1.1 INTRODUCTION

a. The Esterline Angus Miniservo Model MS411B is a compact strip-chart recorder designed for all laboratory, industrial, and general field applications. The MS411B is a portable bench-top, AC operated recorder. Operating on a null-balance potentiometric principle, it offers the sensitivity, response, and reliability of much more sophisicated servo recorders. The writing system features a single disposable ink cartridge that snaps easily into position at the front of the instrument.

b. Twelve switch-selectable recording spans are provided, ranging from 1 mV to 100 V full scale. A twelve-speed stepper chart drive permits the selection of chart speeds from 2 to 60 cm/hr or cm/min, and the Z-fold strip chart has a full 10 cm calibrated span.

c. The Pulse-Input-Proportional (PIP) feature allows external sources to move the chart in direct proportion to time, or some quantity other than time. Maximum input frequency is 10 kHz and internal dividers, which are front panel selectable, are used to divide the frequency to less than 120 Hz.

1.2 SPECIFICATIONS

All electrical and mechanical characteristics of the standard Model MS411B Miniservo recorder are listed in Table 1-1.

Table 1-1. Technical Specifications.

INSTRUMENT TYPE	Portable, single-channel, strip-chart recorder.
RECORDING SYSTEM:	
Method of Writing	Cable-driven, disposable cartridge with integral marking tip and ink supply.
Step Response Time	0.5 seconds full scale.
Pen Lifter	Manual front-panel lever.
Chart Paper	Z-fold, rectilinear with 10cm active span; 20m long with 5cm folds. Roll charts 35m long available.
Scale Plate	Removable type with right-hand zero.
MEASURING SYSTEM:	
Recording Spans	1, 5, 10, 20, 50 and 100mV and Volts. Six-position selector switch provided.
Source Impedance	10,000 ohms maximum on all spans.
Input Impedance	Potentiometric to 100mV; 1 megohm on 1V and above.
Common Mode Rejection: DC	120dB, 100 VDC maximum.
Common Mode Rejection: AC	100dB, 50V rms line frequency maximum.
Input Overload: Continuous	60 VDC on 1mV to 100mV spans; 100 VDC on 1V to 100V spans.
Measurement Accuracy	±0.5% of span with 2μV/°C maximum offset drift.
Deadband	0.3% of span (maximum)
Ambient Temperature Range	0 to 50°C (operating and storage).
Preamplifier	Chopperless integrated circuit design with multi-range and zero offset ±100%.
Servo Amplifier	All Solid-state PC board includes position and velocity feedback design.
Controls	Zero, Span and Volts/Millivolts provided on front panel.
Signal Input Connections	Hi (+), Lo (-), and ground (⏚) banana jacks provided on front panel.
Servo Balance Motor	Sealed, permanent-magnet rotary DC.
Feedback Potentiometer	Sealed, conductive plastic.

Table 1-1. Technical Specifications. (Cont'd)

CHART DRIVE SYSTEM:	
Drive Source	Electronic controlled stepper motor, with PIP.
Chart Speeds	2,5,10,15,30 and 60 cm/hr and cm/min.
Controls	Six-position CM selector, Hour/Minute and chart OFF/ON switches provided on front panel.
Transport Features	Front loading dual-ended sprocket drive, slide-out chart accumulator, thumbwheel advance, and chart tear-off bar.
POWER REQUIREMENTS:	115V or 230V @60Hz, switch selectable with optional 5:6 chart drive sprocket available for 50Hz operation. Fuse protection provided.
INSTRUMENT CASE:	
Style	Portable/bench top with carrying handle and foot rests.
Size	10" wide x 6-1/2" high x 14-7/8" deep. (254mm W x 165.1mm H x 377.8mm D).
Weight	11.5 pounds, (5.2 kg.)

1.3 THEORY OF OPERATION

All principal electronic circuits of the Model MS411B Miniservo recorder are constructed on modular printed-circuit boards. The complete measuring system is illustrated in the simplified block diagram of Figure 1-1. Analog signals to be recorded are first applied to V/OFF/MV switch S-6. This switch then routes the signals either directly (for spans of 1V or less), or through a voltage divider consisting of resistors, to an input filter/limiter network on preamp board PCB201. This network rejects stray interference and includes a pair of zener diodes (CR203 and CR204) for input overload projection.

1.3.1 PREAMP

a. After the signal leaves the input network, it is next amplified by preamp IC202--an integrated-circuit opamp. Gain of this stage is regulated by a closed feedback loop, consisting of resistor R206 and voltage divider resistors. Span switch S-5 is used to select a precision feedback network for each of the twelve spans provided. Offset potentiometer R209 is adjusted for optimum offset drift over normal operating temperature limits of IC202.

b. From the output of IC202, the amplified signal E_S is fed to a voltage-summing network. This network is located on PCB101--a servo amp board mounted within the inner-chassis assembly. In addition to E_S, the summing network also receives two other voltages--gain regulating voltage e_g from a feedback circuit in the servo amplifier loop, and zeroing voltage E_Z that is established by zero-adjust R1 and its accompanying regulator IC201. This system provides a zero adjustment over $\pm$100% of the chart span. E_Z, like E_S is fed to the summing network.

c. At the output of the summing network, zeroing voltage E_Z and gain-regulating voltage e_g are combined with the amplified analog signal E_S to form a conditioned signal voltage e_C. This resultant signal is then applied to the first stage of the basic servo-measuring loop.

1.3.2 SERVO AMP

a. Signal voltage e_C from the summing circuit is connected to the inverting input of differential amplifier IC1. The non-inverting input of this opamp receives a composite feedback signal E_F, which is made up of voltages E_P and e_V.

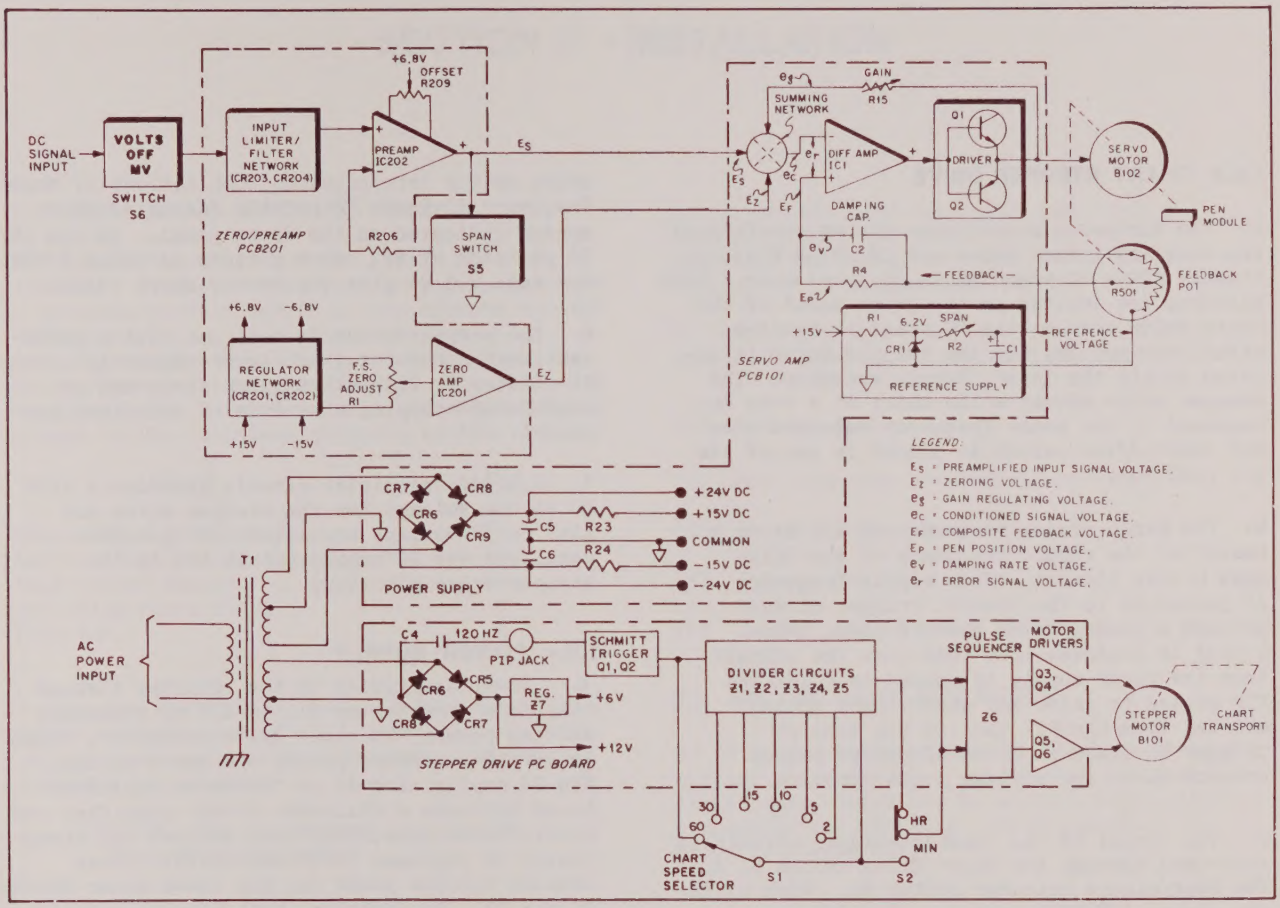


Figure 1-1. Functional Block Diagram.

Voltage E_p is directly proportional to the position of the wiper arm on feedback pot R501 (equivalent to pen position). Damping rate voltage e_v is also picked off at the arm of the feedback pot through differentiating capacitor C2. This dynamic voltage depends upon velocity of the servo motor; and it is therefore effective only when the system is approaching balance, thus helping the motor to anticipate the correct stopping point. The value of C2 has been selected for optimum response characteristics.

b. The differential amplifier compares the analog signal e_c with the feedback signal E_F and, under "off-null" conditions, an error signal voltage e_r is developed at the differential input of IC1. This signal is amplified and then fed to an output driver stage. The driver makes use of complimentary power transistors Q1 and Q2 which, in turn, deliver a DC voltage to the armature of servo motor B102. Drive voltage is applied until the "follow-up" feedback pot reaches a voltage position equal to e_c. At this point the system is "balanced", and the recording pen will come to rest at a new position on the chart. The error signal voltage, which is generated within the measuring system, may be expressed in simplified form as follows:

$$e_r = E_S \pm (E_Z + e_g) \pm E_p + e_v$$

or:

$$e_r = e_c \pm E_F$$

c. Reference voltage for feedback pot R501 is derived from an adjustable temperature-compensated circuit on the servo amplifier board. In this auxiliary supply, R1 reduces the +15 V source to +6.2 V which, in turn, is regulated by zener diode CR1. Span control R2 is provided for calibration while C1 serves as a filter capacitor.

1.3.3 CHART STEPPER DRIVE

a. The Miniservo chart drive system consists of two switches (chart drive and CM/HR/CM/MIN), a stepper drive PC board and a stepper motor. Both switches are located on the front panel of the chart drive module, the PC board is mounted within the module, and the stepper motor is located within the inner chassis assembly. The stepper motor advances the chart at a rate determined by the pulse frequency selected when the chart drive switch is placed in one of its six positions.

b. The basic timing frequency of 120 Hz is a result of the ripple frequency of the full-wave bridge circuit. This ripple frequency is passed on to the Schmitt trigger circuit through a capacitor C4 and PIP jack. When a plug is inserted into this jack the circuit from the power supply is opened to allow the PIP pulses to drive the chart. All pulses are fed from the PIP jack to the Schmitt trigger to shape input waveforms to pulses acceptable to the divider logic circuits.

c. The output of the Schmitt trigger circuit is connected through the chart drive switch S1 to the hour/minute selector switch S2. With S2 in the minute (CM/MIN) position, the 120 Hz pulses are fed to two pulse sequencers, IC Z6a and b. Z6 is dual flip flop that triggers alternate pairs of windings of the stepper motor through driver transistors Q3 through Q6.

d. The 120 Hz output of the Schmitt trigger is also divided by 2 and 4 by Z1 which provides 60 and 30 Hz pulses to drive the chart at 30 and 15 cm respectively. Z2a and b further divide the 60 Hz to 20 Hz and Z3 divides the 20 Hz to 10 and 4 Hz for 10, 5 and 2 cm chart speeds. The chart drive switch interconnects combinations of these frequency dividers to provide specified chart speeds indicated on the front panel. In the CM/HR position of S2, other divider circuits (÷60) are selected to give the hourly chart rates.

e. The stepper motor is designed with a permanent magnet rotor and an electro-magnetic stator. It rotates in discrete angular steps and is capable of stepping a maximum of 120 times per second.

f. A bridge rectifier circuit provides a +12V DC source voltage for the stepper motor and also to Z7 voltage regulator. Z7 provides a regulated +6V DC supply to all ICs in the stepper-drive circuitry.

1.3.4 POWER SUPPLY

a. Power is applied to the recorder through step-down transformer T1. A 12V AC secondary winding powers the chart drive circuitry, while an 18V AC secondary powers the servo system. The DC supply circuit on the servo amplifier board includes a full-wave bridge rectifier and boost-filter capacitors that deliver two unregulated DC voltages (+24V and -24V). These sources furnish power for the servo motor driver, Q1 and Q2. In addition, both 24-volt polarities are dropped down to produce a +15-volt source and a -15-volt source. These sources are zener regulated and supply operating potentials for all other stages in the servo system.

b. In the auxiliary reference supply, resistor R1 and zener diode CR1 reduce the +15V source to +6.2V (±5%). This stable temperature-compensated voltage is then utilized as a reference potential for the solid-state feedback pot (R501A). Span control (R2) is provided in the circuit for full-scale calibration adjustment.

SECTION 2 - INSTALLATION

2.1 UNPACKING INSTRUCTIONS

a. Examine packing case for damage prior to opening. If the packing case shows damage, make a notation to that effect on the express receipt or freight bill. If the shipment within is damaged, notify the carrier and your Esterline Angus representative immediately. The following standard items have been inspected and carefully packed in the Miniservo shipping carton.

ITEM	QTY.
Recording Instrument	1
Service Kit (Inking Accessories)	1
Instruction Manual	1
Recording Chart (Blank)	1
Fuse Kit	1

b. Remove the packing material from the carton carefully and check off all items listed on the packing slip as they are unpacked. Inspect all contents for damage.

CAUTION: Do not attempt to operate a damaged instrument.

c. Instruments are carefully inspected and properly calibrated at the factory prior to shipping, and should be ready for operation as soon as it is unpacked and set up.

d. Setting up the instrument for operation basically consists of the following procedures:

(1) Install proper fuse.

(2) Note mounting considerations.

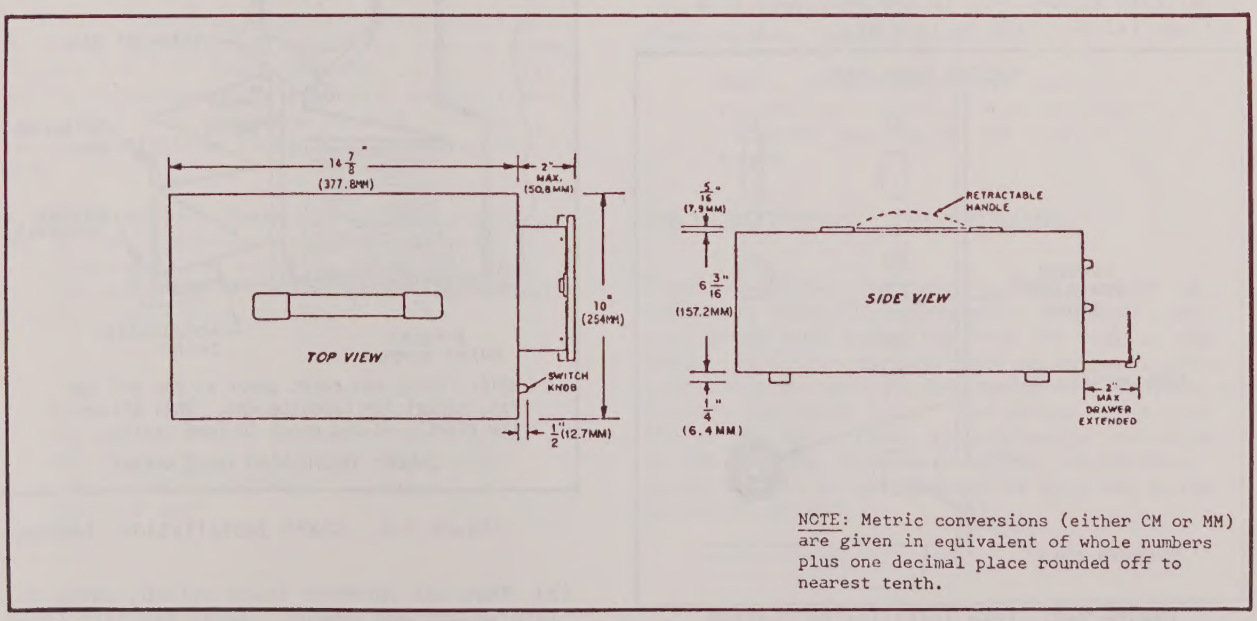
(3) Install chart paper.

(4) Install pen module.

(5) Connect analog input signal.

2.2 INSTRUMENT MOUNTING

a. This recording instrument has been designed primarily for portable and bench-top applications; and, therefore, no special installation procedures are required. Case dimensions are shown in Figure 2-1.



NOTE: Metric conversions (either CM or MM) are given in equivalent of whole numbers plus one decimal place rounded off to nearest tenth.

Figure 2-1. Instrument Dimensional Diagram.

b. Four rubber feet are adhesively-attached to the bottom of the instrument to protect supporting surfaces. The unit should normally be operated in a horizontal plane; however, it may be tilted backward up to 20 degrees without hindering the automatic function of refolding used chart.

c. Preferably, the recorder should be positioned in a clean well-lighted location that affords convenient access to the operator. It should not be subjected to excessive vibration or extreme temperature and humidity conditions. If excessive dust, moisture or corrosive fumes are present, a properly-vented enclosure should be used to protect the instrument.

2.3 INSTALLING FUSE

a. The MS411B is shipped with a fuse kit to allow either 115V or 230V AC operation. Before placing the Miniservo into operation, fuse must be installed and the power mode switch set for proper line voltage. A fuse kit, 752A538, is provided to allow the MS411B to operate on either 115V or 230V AC.

NOTE: For 50 Hz operation another chart motor pulley must be installed. This is supplied in Kit No. 723A141.

The Miniservo recorder may be set to operate on either 115 or 230V by the following steps:

NOTE: Do not apply power to Miniservo at this time.

1. Set POWER MODE switch located on the rear panel (see Figure 2-2) to desired power line voltage (either 230V or 115V AC).

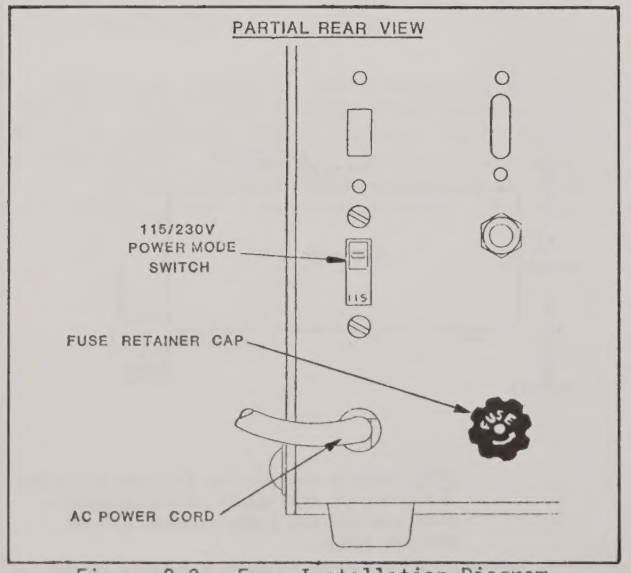


Figure 2-2. Fuse Installation Diagram.

2. Remove fuse holder retainer cap by turning the cap in the direction of the arrow.

NOTE: Two fuses are provided, a ½ amp for 115V operation and a ¼ amp for 230V operation.

3. Select proper fuse and place into fuse holder. Replace cap by turning in opposite direction of arrow.

b. The MS411B is now ready to receive power.

2.4 CHART INSTALLATION

Only Esterline Angus precision charts should be used in this instrument for guaranteed accuracy and optimum performance. To ensure continuous records, inspect the recorder periodically for its remaining chart supply. Always keep enough charts on hand to operate the recorder for at least one month. Charts must be ordered by assigned numbers, which are printed along the right-hand margin on each chart.

2.4.1 CHARTING PROCEDURES

To install chart paper in the recorder, refer to the chart threading illustration in Figure 2-3 and proceed with the following steps:

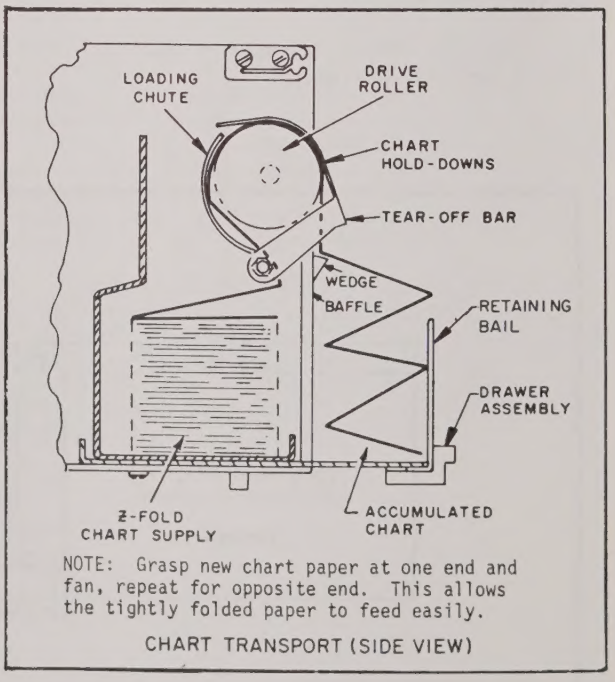


Figure 2-3. Chart Installation Diagram.

(1) Turn off recorder Power switch, swing scale-plate upward and remove. Raise Pen Lift Lever

located at left end of chart-drive roller. Pull front drawer assembly forward against its stops.

(2) Squeeze retaining bail to disengage it from drawer slots; then lift bail out. Grasp center wedge attached to hinged baffle, and pivot baffle downward.

(3) Remove Z-fold chart pack from its container. Orient pack so that edge with elongated holes is on left-hand side and printed side of paper will face recorder as chart unfolds from top of pack. Slide pack back into supply compartment through front baffled opening.

(4) Pull out a few inches of chart from top of supply pack and insert end of chart between loading chute and drive roller, as shown in Figure 2-3.

(5) Thread chart over top of drive roller and under tear-off bar by rotating thumbwheel on right end of drive roller until leading edge of chart is just behind bar. See that roller pins engage perforations at both edges of chart.

NOTE: If any chart paper is protruding from supply compartment, carefully fold it back into its original configuration.

(6) Pivot baffle upward, and snap into position by pressing on both top-front corners. Replace wire bail.

(7) Rotate thumbwheel downward until chart enters drawer assembly and begins to fold as shown in Figure 2-3. If chart does not automatically start to refold properly at first, manually position first fold to ensure correct folding. Allow at least three folds to accumulate in drawer.

(8) Lower Pen Lift lever and replace scaleplate by inserting top edge in first; then swing plate downward until it snaps into position. To check operation, turn on Power switch and select chart speed desired.

NOTE: A 1/8" wide, blue line starting approximately one meter (36") from end of chart in left-hand margin will give operator warning that end of chart is near.

2.5 INK CARTRIDGE INSTALLATION

A one piece pen-and-ink cartridge is employed in the writing system. This plug-in disposable module contains red ink and is supplied in the recorder accessory kit with a snap-on scaleplate pointer. To ensure continuous records, check supply of ink in cartridge when changing chart packs. Each cartridge holds ink for approximately 3600 feet of chart trace. Always keep a supply of cartridges on hand to operate the recorder for at least one month. Replacement cartridges are available in convenient six packs.

2.5.1 INKING PROCEDURES

To install an ink cartridge, proceed with the following steps:

(1) Remove ink cartridge and scaleplate pointer from package supplied. Slide pointer onto cartridge pen staff until it snaps over top of cartridge.

(2) Turn off power switch, raise Pen Lift lever, and swing scaleplate upward and remove.

(3) Remove the protective cap from pen tip and, with pen tip facing down, insert module straight back into cartridge holder.

(4) Lower Pen Lift lever and replace scaleplate by inserting top edge in first; then swing plate downward until it snaps into position. With chart installed, select a chart speed, turn on Power switch, and check operation.

NOTE: Retain protective cap to replace on cartridge when recorder is to be inoperative for over 24 hours.

2.6 ELECTRICAL CONNECTIONS

Power to operate the bench-styled recorder is conducted through a permanently attached three-wire power cord extending from the rear of the case. It is recommended that an external ground connection be made to the instrument--preferably through the power cord. The ground input jack (⏚) on the front panel is internally connected to the recorder chassis; however, an external ground should be established at only one point on the instrument.

2.6.1 ANALOG SIGNAL CONNECTIONS

Analog signal sources are connected to the front-panel input jacks as shown in Figure 2-4. For an up-scale deflection, the positive signal is connected to the "HI+" jack and the negative signal to the "LO-" jack. Refer to paragraph 2.6.2 for suggested input-signal shielding and grounding techniques.

CAUTION: Common mode voltage must NOT exceed a maximum of 150 VDC.

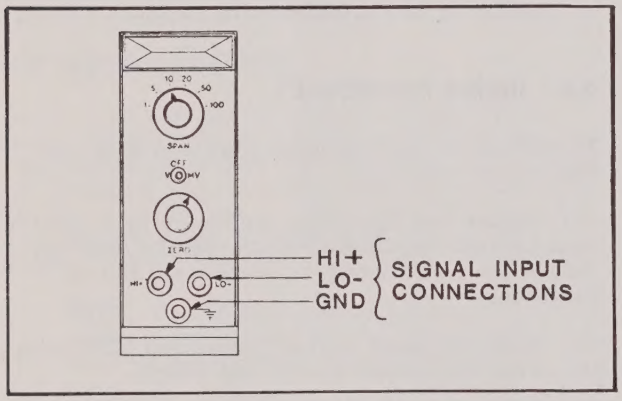


Figure 2-4. Signal Connections.

2.6.2 SHIELDING & GROUNDING

a. For most applications, signal input connections may be made with a single-wire shielded cable or unshielded leads as shown in Figure 2-5A & B. For low-level signals in "noisy" areas, however, a two-wire shielded cable is recommended (see wiring examples in Figure 2-5C).

b. The presence of external interference (or stray pickup) may be indicated by a slight vibration of the pen, zero shifting, excessive deadband, or any combination of these effects. Such conditions can usually be eliminated by use of proper shielding and grounding techinques.

c. In applications where the source of stray pickup is unknown, the ideal operating condition may best be found by experimenting with the different connection configurations shown in Figure 2-5. If unsatisfactory operation still exists and it is established that relatively high AC signals are present, it may be necessary to insert a low-pass RC filter across the output of the signal source

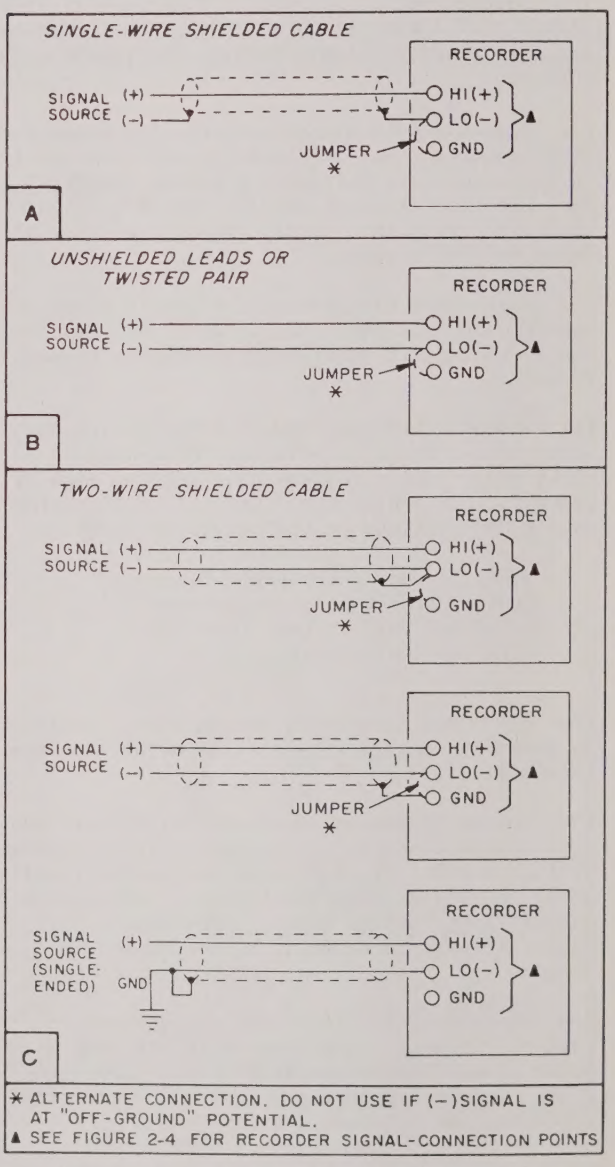


Figure 2-5. Signal Shielding & Grounding.

SECTION 3 - OPERATION

3.1 GENERAL

This section of the manual includes complete operating instructions for the AC operated Miniservo recorder. No attempt should be made to operate the instrument until all instructions have been thoroughly studied. The normal care when handling any precision piece of equipment should be exercised.

3.2 OPERATING CONTROLS

All operating controls for the portable Miniservo recorder are illustrated in Figure 3-1. Basic control functions are delineated in the following paragraphs.

3.2.1 FRONT PANEL CONTROLS

a. POWER SWITCH: This is a two-position slide switch that controls AC power to both servo and chart-drive systems. To energize the recorder, move the switch to its "ON" position. Always place the switch in its "OFF" position when recorder is not in use, or when charting, inking or servicing the unit.

b. PEN LIFT (LEVER): The small metal arm located at the left end of the scaleplate is a pen lift lever. This device permits the operator to raise or lower the recording pen as desired. To raise the pen from the chart, merely move the lever arm upward. The pen can be lowered to its recording position by moving the lever downward.

c. CHART ADVANCE (THUMBWHEEL): This mechanical adjustment is provided so that the operator can advance the chart paper manually. Rotating the wheel downward overrides the internal drive system and propels the chart forward. This control should always be used when charting the instrument.

d. CHART SPEED SWITCH: This six-position rotary switch offers the operator a selection of six different centimeter feed rates for both minute and hour chart speeds. It may be rotated in either direction with power off or with the chart in motion.

e. HOUR/MINUTE SWITCH: A two-position slide-type switch that is used to select either hour speeds or minute speeds for any feed rate setting. The switch may be operated while the chart is in motion.

f. CHART ON/OFF SWITCH: This two-position slide-type switch controls power to the chart drive PC board. Place this switch in its "ON" position to start the chart drive, and in its "OFF" position to stop the chart. This switch may be used during calibration to conserve chart paper.

g. SPAN SELECTOR SWITCH: A six-position rotary switch to select any one of six different measuring and recording spans.

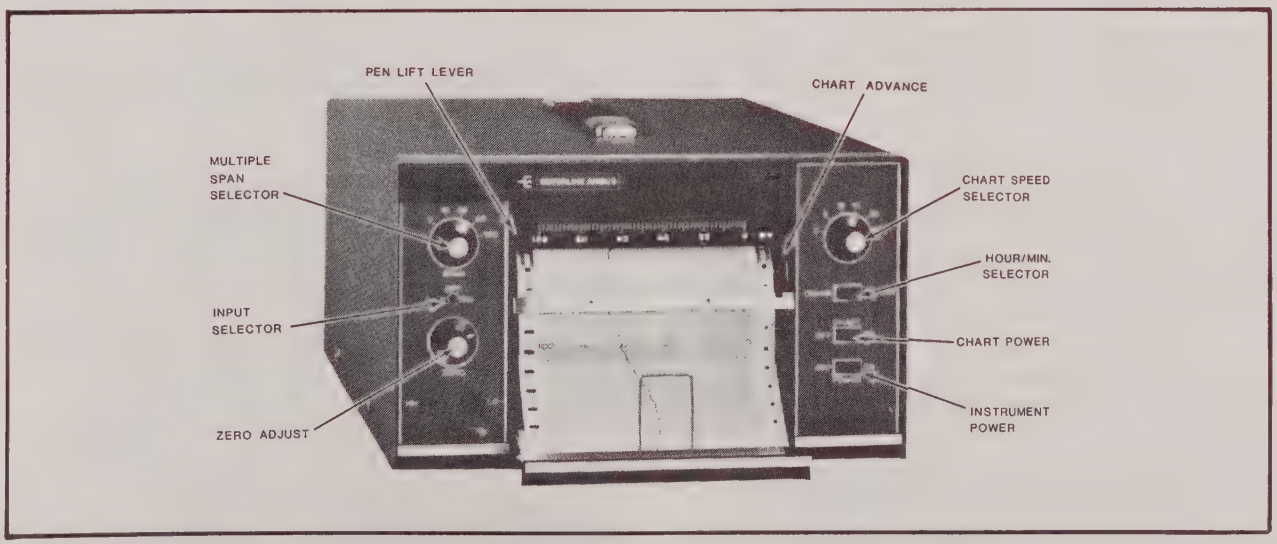


Figure 3-1. Location of Operator Controls.

h. V/OFF/MV SELECTOR SWITCH: A three-position toggle switch allows either input voltages from 1V to 100V or millivolt (mV) 1 to 999mV. The OFF position effectively shorts the preamplifier inputs for calibration.

i. ZERO POTENTIOMETER: A vernier-type potentiometer used to zero the writing pen on chart or to suppress or elevate zero to some desired level.

3.2.2 REAR PANEL CONTROLS

a. 115-230V AC SELECTION SWITCH: A two position slide switch selects either 115V or 230V AC operation. Up position allows 115 volt AC operation, while the down position permits 230V AC operation.

b. PIP INPUT JACK: Connects user provided pulses to drive chart at the input pulse rate. A three-conductor plug is provided in the recorder accessory package.

3.3 OPERATION

a. The following assumes that the chart paper, writing pen have been previously installed.

b. To place the MS411B Miniservo into operation proceed as follows:

(1) Instrument power should be OFF.

(2) CM/HR-CM/MIN switch - Preset to give desired chart speed per hour (HR) or per minute (MIN) rate.

(3) Chart Speed Selector switch - Set to give best resolution of input signal; i.e., a rapidly changing input signal would require a fast chart speed for good readability.

(4) Zero Adjustment - Set V/OFF/MV switch to OFF position. Turn POWER switch ON. Adjust zero potentiometer to place writing pen on the chart zero reference line. If the writing pen is raised off the chart, use the pen lift lever to lower the pen on the chart. CHART switch may be placed in ON position if desired. Turn instrument power OFF.

> NOTE: To elevate or suppress zero, see paragraphs 3.3.2 and 3.3.3.

c. Connect input leads to the recorder, observing polarity. Turn instrument power ON, the recorder should immediately indicate input voltage. Observe chart speed, use slowest speed necessary for optimum use of chart paper. Chart speed switch may be adjusted while the instrument is operating.

3.3.1 ZERO OFFSET

a. Zero control not only affords the operator conventional zero pen positioning but also provides a means for offsetting electrical zero. With this feature, the operator may shift a selected measurement span so that a more detailed record of a specific analog variable is obtained with maximum resolution.

b. If negative or both positive and negative signal excursions are to be recorded, electrical zero may be shifted up-scale (elevated) from 0 to +100% of the selected chart span. If the input signal range is greater than the upper limit of the span selected, electrical zero may be shifted down-scale (suppressed) from 0 to -100% of the chart span.

3.3.2 ZERO ELEVATION

a. Electrical zero can be shifted up-scale (elevated) from chart or scale "0" to full scale for any selected recording span; therefore, the Miniservo can be adjusted to record negative or both positive and negative input signals. Zero may be elevated by the following procedure:

> CAUTION: Signal input must not exceed ±100V, regardless of offset adjustment.

(1) Set V/OFF/MV switch to OFF position.

(2) Place span switch in desired span position, turn on power switch, and permit instrument to warm up for ten minutes.

(3) Determine desired zero pen position on chart or scale. Lower-end value of input signal range equals minimum amount of zero elevation required--disregarding negative sign of input signal voltage.

> NOTE: If scale calibrations are not directly proportional to selected span, calculate equivalent percentage point on scale.

(4) Carefully adjust Zero control until recording pen moves up-scale to point determined in step (3).

(5) Set V/OFF/MV switch to measure (V or MV) input signal and connect signal source to be measured. Instrument will now record analog inputs over offset range selected.

b. EXAMPLE: Assume an analog source having maximum signal deviations of from -13 mV to +65 mV. The total desired measurement range is thus 78 mV. To encompass this signal range, an available recorder span of 100 mV is selected. Since the selected span is 22 mV greater than the anticipated signal range, 11 mV may be added to each end of the range so that all measurements will be centered within the given chart span. Adding 11 mV to the lower-end value of the signal range (-13 mV), results in a total required elevation of 24 mV (disregarding sign). Zero control is then adjusted for an elevated pen position equivalent to 24 mV on the chart or scale. The recorder will now operate over the desired input signal range with a full-span calibration of from -24 mV to +76 mV.

3.3.3 ZERO SUPPRESSION

a. When source signals are to be recorded that are above the upper limit of an available span, electrical zero may be shifted down-scale (suppressed) as much as one full span from chart or scale "0". Zero may be suppressed by the following procedure:

> CAUTION: Signal input must not exceed ±100 V, regardless of offset adjustment.

(1) Disconnect analog source, place span switch in desired span position, turn on power switch and permit instrument to warm up for ten minutes.

(2) Using known-accurate voltage standard, apply input signal to recorder that equals low-end value of desired measurement range. Recording pen will deflect to equivalent position on chart span.

> NOTE: If scale calibrations are not directly proportional to selected span, calculate equivalent percentage point on scale.

(3) Carefully adjust Zero control until recording pen moves down-scale and comes to rest precisely on "0" reference line of chart.

> NOTE: Scale "0" now electrically represents low end of desired measurement range.

(4) Disconnect voltage standard from recorder input and connect signal source to be measured. Instrument will now record analog inputs over offset range selected.

b. EXAMPLE: Assume an analog source having maximum signal deviations from +15 V to +55 V. The total signal range is thus 40 V. To encompass this measurement range, an available span of 50 V is selected. Since the recorder span is 10 V greater than the anticipated range, each end of the signal range may be shifted 5 V to center all measurements on the chart span. Subtracting 5 V from the lower-end value of the signal range (+15 V), results in a required zero suppression of 10 V. A reference source of precisely +10 V is applied to the recorder input and Zero is then adjusted until the recording pen comes to rest on chart "0". The reference source is removed and the recorder is now set up to operate over the desired input signal range with a span calibration of from +10 V to +60 V.

3.3.4 PIP OPERATION

a. A rear panel jack is provided to allow pulses from external sources to move the chart in direct proportion to time, or some quantity other than time. Maximum stepper-motor frequency is 120 Hz, which moves the chart approximately 24 inches (60 cm) per minute. If the input pulse rate exceeds 120 pulses/second, internal dividers (front panel selectable) may be used to divide the frequency to 120 Hz or less. The pulse division ratios are listed in Table 3-1. Maximum input pulse rate is 10 kHz. External wiring to a function generator, transducer or TTL logic signals is required to either manually or automatically actuate or stop the drive.

b. The chart drive signal may be a sine, square, triangular, or similar non-symmetrical wave having a positive-going peak of suitable amplitude and duration (see Figure 3-2 for typical input wave forms). The positive peak must have a pulse width of 50 microseconds (minimum) at the one volt point. This signal must be relatively free of transient interference to avoid erratic triggering of the stepper motor. Note that the signal does not have to go negative.

c. For inputs of pulse frequencies above 120 Hz, the internal dividers must be used to divide the input signal to 120 Hz or less. The dividers are switched in by the Chart Speed switch. Table 3-1 gives the pulse division ratios that may be obtained through this switch.

d. When pulse-frequency reduction is necessary, the chart speed in cm/minute may be determined by the following formula:

$$S = \frac{60(PS)}{R120} \qquad \text{Simplified } S = \frac{PS}{2R}$$

Where: S = Chart speed in cm per minute.
PS = Input pulses per second
R = Pulse division ratio.

Table 3-1. Pulse Division Ratio.

Frequency Dividing Ratio	PANEL SWITCH POSITIONS	
	Chart Speed (cm)	CM/HR - CM/MIN
1	60	Min.
2	30	Min.
4	15	Min.
6	10	Min.
12	5	Min.
30	2	Min.
60	60	Hr.
120	30	Hr.
240	15	Hr.
360	10	Hr.
720	5	Hr.
1800	2	Hr.

e. When the Miniservo recorder is to be operated with PIP control, a mating plug for the external source is provided. The connections for this three-conductor plug are shown in Figure 3-3.

NOTE: Plug configurations may vary with different manufacturers. Ensure, with an ohmmeter if necessary, that connections are as shown; i.e. + signal to plug tip and signal common to center of plug.

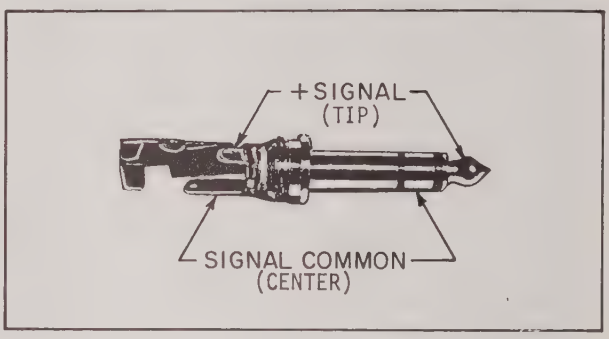


Figure 3-3. PIP Input Connector.

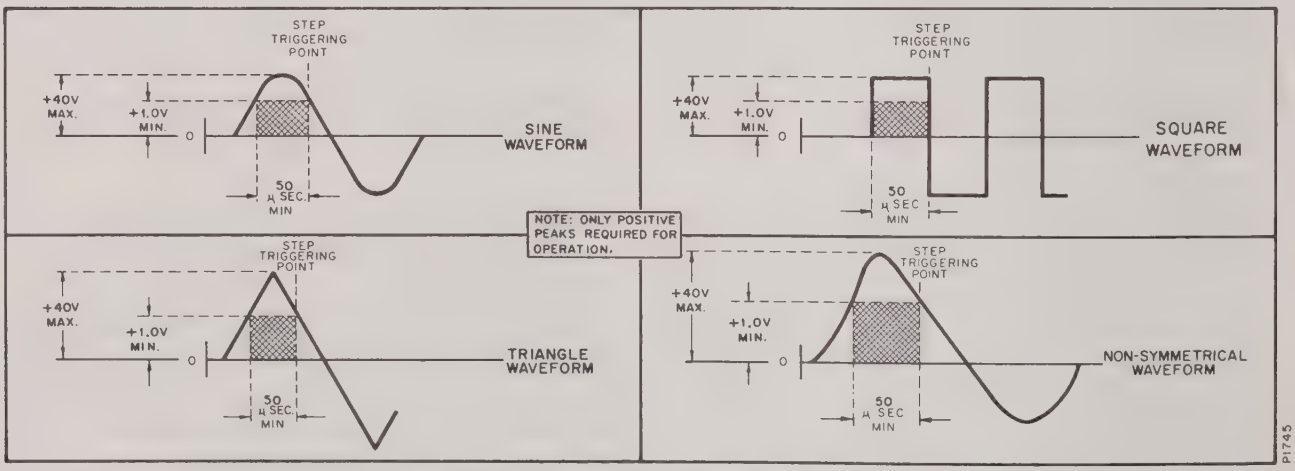


Figure 3-2. Typical PIP Input Waveforms.

SECTION 4 - MAINTENANCE

4.1 GENERAL

The MINISERVO, designed for long trouble free operation, should require little attention in the field. Periodic maintenance schedules should be established and followed, however, to ensure optimum performance. Where extreme temperatures or contaminated atmospheres prevail, maintenance should be performed more often. Since frequency of use and environmental conditions will vary with applications, maintenance scheduling is left to the discretion of the user. Routine maintenance procedures will primarily entail a complete visual inspection and cleaning. Keeping a simple record of component replacements will be a handy reference during inspection, and will ensure a ready reserve of expendable items to be maintained--such as chart paper and pen modules.

> WARNING: Prior to servicing or cleaning activities, always remove AC power and any other wiring that is potentially dangerous.

4.2 INSPECTION

A complete visual inspection of the instrument should be made at each scheduled maintenance period to detect the possible onset of a malfunction. At that time, check for low chart and ink supplies, accumulation of dirt, damaged or loose hardware, shorted or broken wiring, and loose connections. Also check the reserve of chart packs and ink cartridges to ensure that an adequate supply is on hand.

4.3 CLEANING

a. Regardless of the precautions taken, dirt and dust will enter the recorder chassis area; therefore, periodic cleaning of exposed components within the instrument will be necessary. Always keep the pen tip free of lint and dried ink. To prevent dry-out, replace protective cap on pen tip if recorder will remain inactive for more than 24 hours.

b. Light dirt marks can be removed from case surfaces, scaleplate, and front control panels with a damp, lint-free cloth or sponge. Esterline Angus recording ink is water based and can be removed with a wet cloth. Heavier dirt smudges can be removed with any commercially-available liquid detergent; however, DO NOT use harsh solvents as they may damage certain finishes. Dust and other dry accumulations can be removed from within the recorder with a soft-bristled brush or low-vacuum system.

> CAUTION: Exercise care when cleaning to avoid disturbing electrical wiring and alignment of mechanical parts.

4.4 LUBRICATION

All mechanical friction surfaces, motors, and other moving parts of the recorder are permanently lubricated at the factory; therefore, no further lubrication is required for maintenance purposes.

> CAUTION: DO NOT lubricate cartridge holder bearing or its associated guide rod.

4.5 CALIBRATION

a. Each recorder is precisely calibrated at the factory and should not require further readjustment in the field. If during servicing procedures, however, adjustments have been inadvertently changed, or components associated with the measuring circuits have been replaced--a calibration check and adjustment may be necessary.

b. Recorder calibration can be checked by a direct comparison with a known-accurate standard. The validity of such a test, however, depends upon the accuracy of the reference source--which should be considerably better than accuracy requirements of the recorder. **Before attempting any of the following calibration procedures, the recorder should be allowed to warm up for at least 10 minutes.**

4.5.1 TEST EQUIPMENT REQUIRED

a. Precision ±DC voltage standard with variable millivolt and voltage outputs. Accuracy must be ±0.05% or better.

b. Digital voltmeter with ±0.05% (or better) accuracy, and minimum resolution of 0.01%.

c. Carbon resistor (100K-ohms, +5-10%).

d. Small screwdriver or alignment tool for trim pot adjustments.

4.5.2 PRECALIBRATION INSTRUCTIONS

a. Place front-panel Power and Chart switches in "OFF" positions. Move Pen Lift lever up to raise pen from chart.

b. Remove top cover from recorder. From under base pan, remove two screws securing preamp module to left side of chassis. Slide module forward until access holes are exposed for servo amplifier adjustments.

NOTE: To maintain ground (⏚) continuity, connect short clip lead between preamp jack and unanodized metal on main chassis.

4.5.3 ELECTRICAL CALIBRATION PROCEDURES

Preamp Adjustments:

1. Preset V/OFF/MV switch to the MV position, span switch to "1".

2. Connect a 100K ohm resistor across the input terminals (Hi+ to Lo-).

3. The writing pen may be repositioned to the active chart area; and also chart may be moving for this procedure if desired.

4. Using the pen as an indicator, switch the V/OFF/MV switch to the OFF position. Adjust R208 (see Figure 4-1C) for a no change indication of the pen, while switching between the OFF and MV positions.

5. Remove the 100K ohm resistor.

6. Preset V/OFF/MV switch to the OFF position, span switch to "1".

7. Adjust R209 for a no change indication while switching the SPAN control from "1" to "100" position.

8. Repeat steps 1 through 7 until satisfactory calibration is achieved.

Servo Amp Adjustments:

(1) Position servo-amp Gain control (R15) to its approximate mid-range point. This trim pot is located on servo amplifier PC board. It is accessible from left side of chassis (Fig. 4.1A).

(2) Move Pen Lift lever down to lower recording pen onto chart.

(3) With Instrument Span select switch in proper span position, connect voltage standard to input and set for zero output.

(4) Adjust front-panel Zero control until pen point is positioned on zero reference line of chart. Using thumbwheel, manually advance chart to verify pen-trace position.

(5) Set voltage standard for output equal to full-scale voltage selected in step 3.

(6) Adjust servo-amp Span (R2) until pen point is positioned on full-scale line of chart. This trim pot is located on servo amplifier PC board (see Figure 4-1A). Manually advance chart again to verify position.

(7) Set output of voltage standard so that recording pen is positioned at approximately mid scale. To check deadband, momentarily displace pen position by slightly rotating small pinion gear on top of chassis. Manually advance chart as required to verify pen positions.

(8) Deadband should be within 0.3% of span; if it is not, carefully readjust servo-amp Gain (R15) until deadband is acceptable.

CAUTION: Instability may result if servo gain is set too high.

(9) Repeat steps 3 through 6 and readjust if necessary.

NOTE: A slight interaction between servo Span and Zero adjustments may occur.

(10) Electrical calibration is now complete. Turn off recorder power, disconnect voltage standard, reinstall preamp module, and replace top cover.

4.6 DISASSEMBLY

a. Most of the components and modular assemblies in the recorder are accessible for inspection and servicing by simply removing the instrument cover. Servicing of a few components, such as the servo motor and feedback potentiometer, may also require removal of the inner chassis assembly from the instrument base pan.

b. Basic construction of the inner chassis assembly is shown in Figure 4-2. The chart-drive module, the preamp module, and the servo PC board are replaceable as complete subassemblies. Other

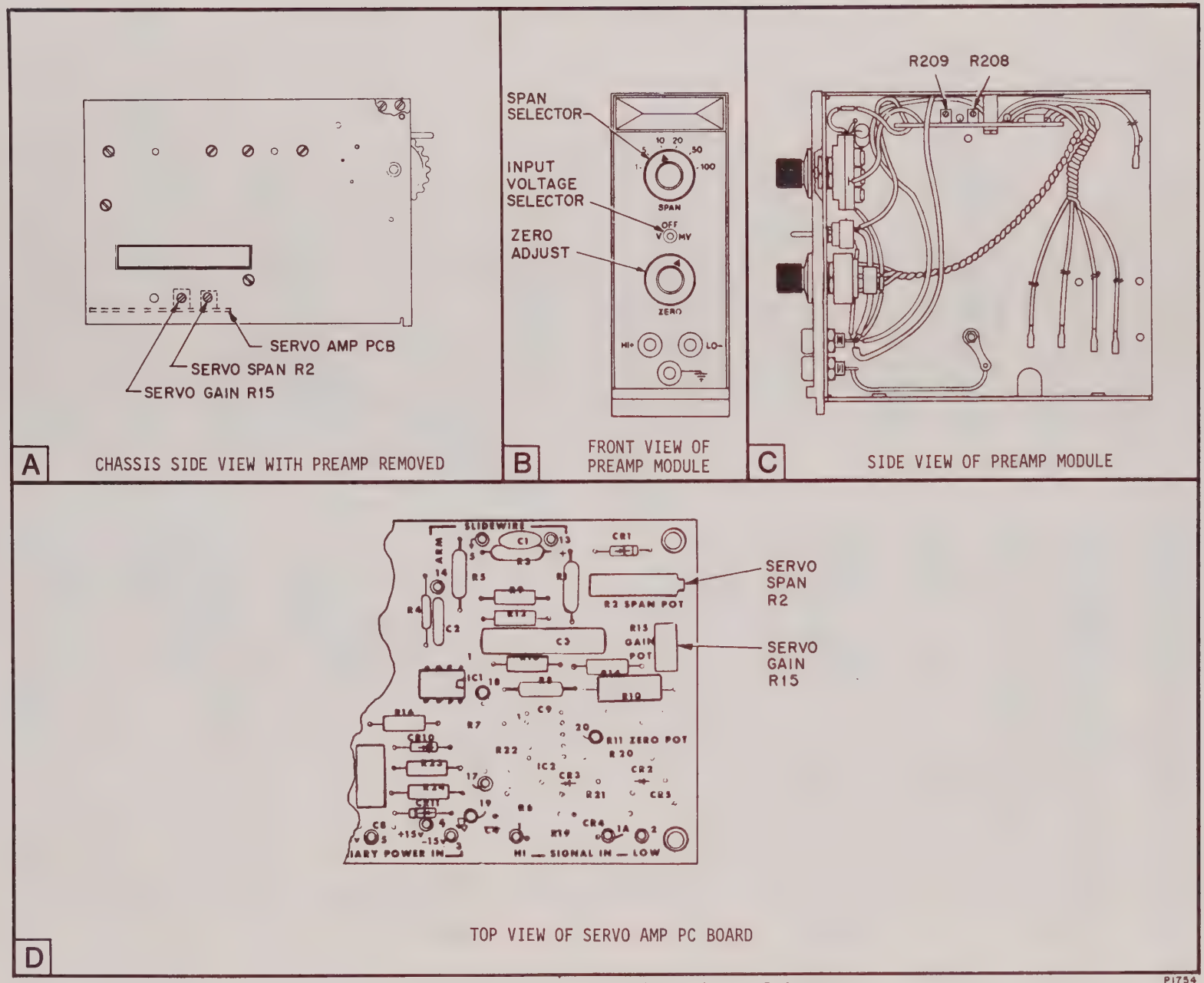


Figure 4-1. Location of Calibration and Test Points.

P1754

components such as the servo motor, feedback potentiometer, and chart-drive stepper motor are also replaceable in the field.

c. The procedures for replacing some of the chassis components are obvious; therefore, detailed instructions for their removal are not given. Some components, however, can best be removed if a definite procedure is followed or if certain precautions are taken.

4.6.1 COVER REMOVAL

To remove the instrument cover, proceed with the following steps:

(1) Place Power switch in its OFF position. Disconnect the AC power cord from its source and remove signal wiring from front-panel jacks.

(2) Remove two screws securing cover on each side of recorder base pan.

(3) Lift cover straight up and off instrument.

4.6.2 INNER CHASSIS ASSEMBLY REMOVAL

To remove inner chassis assembly, proceed with the following steps:

(1) Remove instrument cover as described in paragraph 4.6.1.

(2) From underside of recorder, remove four rear-most screws securing chassis assembly. This will release the servo-amplifier PC board.

(3) Slide board toward the rear and remove all preamp and power circuit leads form board by carefully pulling each lead connector up from its mating terminal post.

CAUTION: Use extreme care NOT to break or loosen pin posts.

(4) Remove chart-drive motor cable connector from stepper drive PC board by pulling connector straight back.

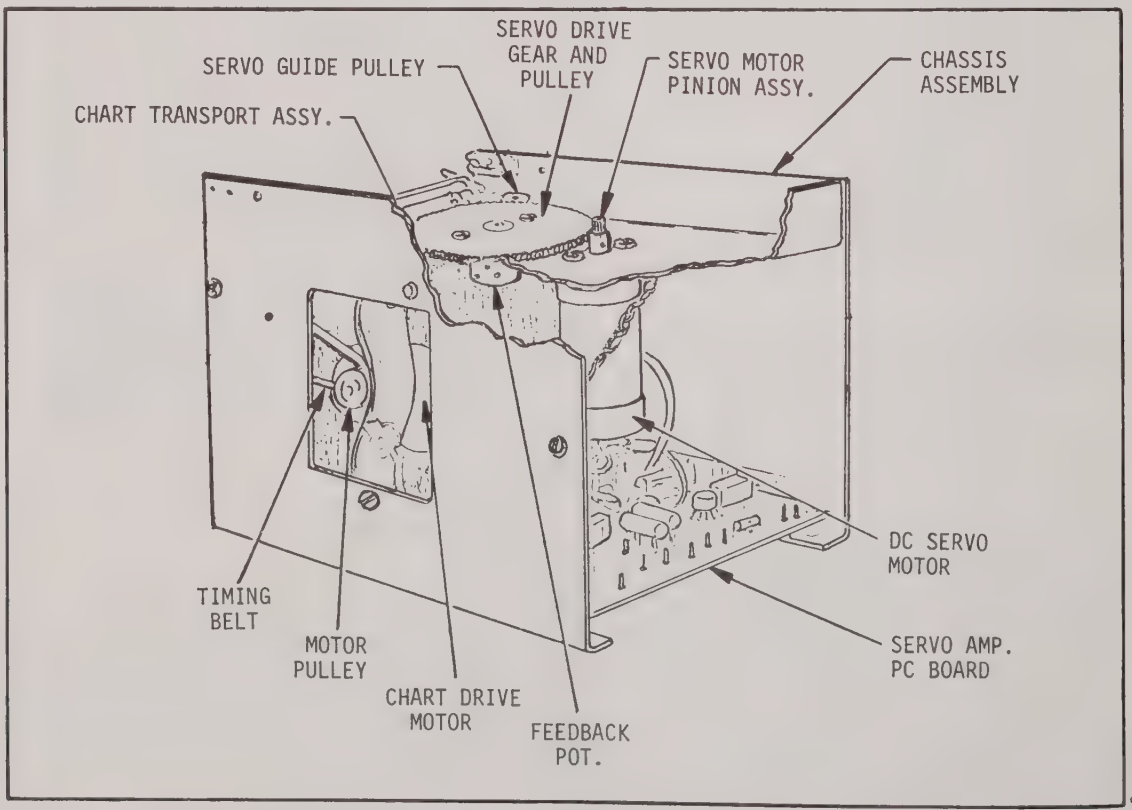


Figure 4-2. Major Components of Inner Chassis Assembly.

CAUTION: DO NOT disturb adjustments or other wiring.

(5) From underside of recorder, remove four forward screws securing chassis to base pan.

(6) Slide chassis back and lift entire assembly from instrument.

NOTE: When reinstalling servo-amp PC board, refer to Figure 4-4 for location of connection points.

4.6.3 PREAMP MODULE REMOVAL

To remove the entire preamp assembly from the left side of the recorder, proceed with the following steps:

(1) Remove instrument cover as described in paragraph 4.6.1.

(2) Disconnect five preamp leads from servo-amp PC board by carefully pulling each removable lead connector straight up from its mating terminal post on board. Use extreme care NOT to break or loosen pin posts.

CAUTION: DO NOT disturb adjustments or other wiring.

(3) From underside of recorder, remove two screws securing preamp assembly to base pan.

(4) Lift entire module from left side of instrument.

NOTE: When reinstalling module, refer to Figure 4-4 for location of connection points.

4.6.4 CHART-DRIVE MODULE REMOVAL

To remove the chart-drive assembly from the right side of the recorder and to remove the stepper-drive PC board, proceed with the following steps:

(1) Turn off recorder Power switch and remove top cover.

(2) From underside of instrument, remove two screws securing module to base pan, and lift entire assembly from recorder.

(3) Carefully remove all connectors from stepper drive PC board.

(4) Disconnect PIP and ground leads from board. Module is now free of all attached wiring.

(5) To remove stepper-drive PC board from chart-drive module, remove four screws securing board to side of module.

(6) Carefully remove switch connector from front edge of PC board, and lift board from module.

4.6.5 SERVO BOARD REMOVAL

To remove the servo amplifier board from the inner chassis assembly, proceed with the following steps.

(1) Remove instrument cover as described in paragraph 4.6.1.

(2) From underside of recorder, remove four screws securing PCB to base pan and inner chassis.

(3) Carefully slide board toward rear and remove clip-on leads from board for servo motor, feedback pot, preamp and rear-panel power circuits. Carefully pull each lead straight upward from board.

CAUTION: Use extreme care NOT to break or loosen pin posts.

(4) Lift entire servo board assembly from instrument.

NOTE: When reinstalling servo-amp PC board, refer to Figure 4-4 for location of connection points.

4.7 DRIVE-CABLE REPLACEMENT

Should the servo drive cable become worn or break, restring with new cable as follows. Refer to stringing diagram shown in Figure 4-3.

(1) Place Power switch in its "OFF" position, remove scaleplate and ink cartridge, and gain access to top of inner chassis.

(2) To remove old cable, remove two screws from top of servo-drive gear and lift gear from top of cable-drive pulley. Loosen two clamping screws on pulley and clamping screw on ink-cartridge holder; then remove old cable. Manually slide ink-cartridge holder to one end of guide rod.

(3) To string new cable, manually turn drive pulley clockwise until its mechanical stop rests against bumper.

(4) Refer to Figure 4-3 and follow numbered arrows. During stringing procedure, leave drive cable unclamped from ink-cartridge holder.

(5) After cable is strung, pull cable taut and secure in place by tightening clamping screws on drive pulley.

(6) Loosen one clamping screw on pulley to permit cable to slip. With finger, press cable down against top plate of chassis at point "X". While holding cable down against plate, retighten clamping screw on drive pulley.

(7) After cable has been secured, check for proper tension as follows:

(a) Place force gauge lever behind cable at point "W". Force it forward until front edge of cable is even with front edge of guide rod. Gauge should read approximately 8 ounces (±0.5 oz.) or 227 grams (±14 grams).

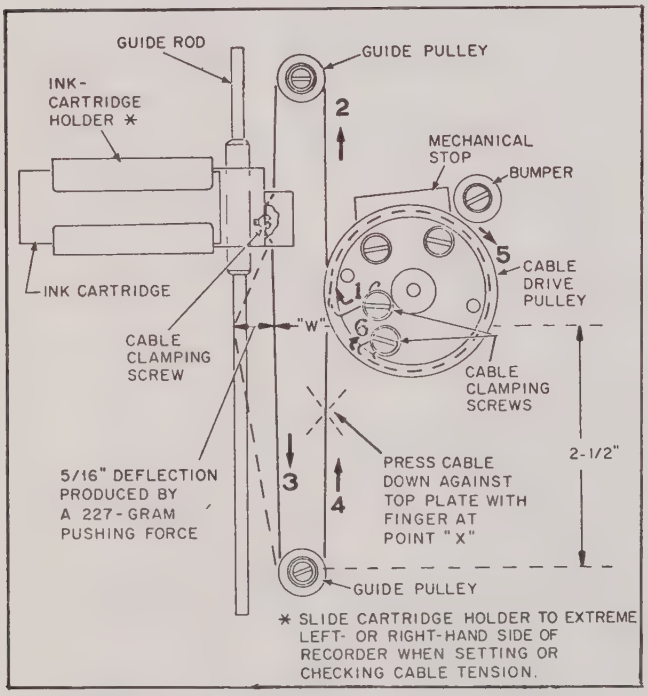


Figure 4-3. Drive Cable Stringing Diagram.

(b) If proper tension is not obtained, loosen one clamping screw on drive pulley; then readjust cable until proper tension is measured.

(c) Manually rotate cable drive pulley against mechanical stops in both directions and check to see that cable moves freely and smoothly. After proper operation is ensured, cut off excess cable at clamping screws.

(8) Clamp cable to ink-cartridge holder as follows:

(a) Reinsert ink cartridge into its holder.

(b) Manually turn drive pulley clockwise until its mechanical stop rests against bumper.

(c) Hold drive pulley stationary, and slide cartridge holder along guide rod until pen point is positioned 3/64" beyond zero baseline on calibrated chart. Slip cable under clamping screw on cartridge holder and tighten clamping screw.

(9) Reinstall servo-drive gear to top of cable drive pulley with two mounting screws. Replace scaleplate.

(10) After drive cable replacement, check recorder calibration and adjust if necessary. Replace top cover and resume normal operation.

4.8 SHUTDOWN

If the recorder is to remain inactive for more than 30 days, disconnect AC power and remove pen cartridge module. If cartridge is to be retained, place red protective cap over pen tip. If instrument is to be transported for a long distance, follow factory packing procedures.

4.9 TROUBLESHOOTING

a. All required wiring diagrams and schematics for the Model MS411B Miniservo recorder are found at the end of this section of the manual. These diagrams provide helpful information for tracing system wiring and for troubleshooting the instrument.

b. If trouble is indicated in the electrical measuring system, the most logical troubleshooting approach is to isolate the fault to an electrical module or component--such as a servo amplifier board or a feedback pot. Voltage and current measurements, continuity checks, and DC resistance measurements may be necessary to pinpoint the trouble.

CAUTION: Always turn off power before making DC continuity checks or resistance measurements.

c. The stepper-drive PC board assembly is largely composed of solid-state components with liberal use of CMOS (complementary metal oxide semi-conductor) integrated circuit devices. Input protection networks designed into these devices are effective in preventing damage in a wide variety of handling and operating situations. However, one should follow handling instructions recommended by the manufacturer when servicing circuits having such sensitive devices.

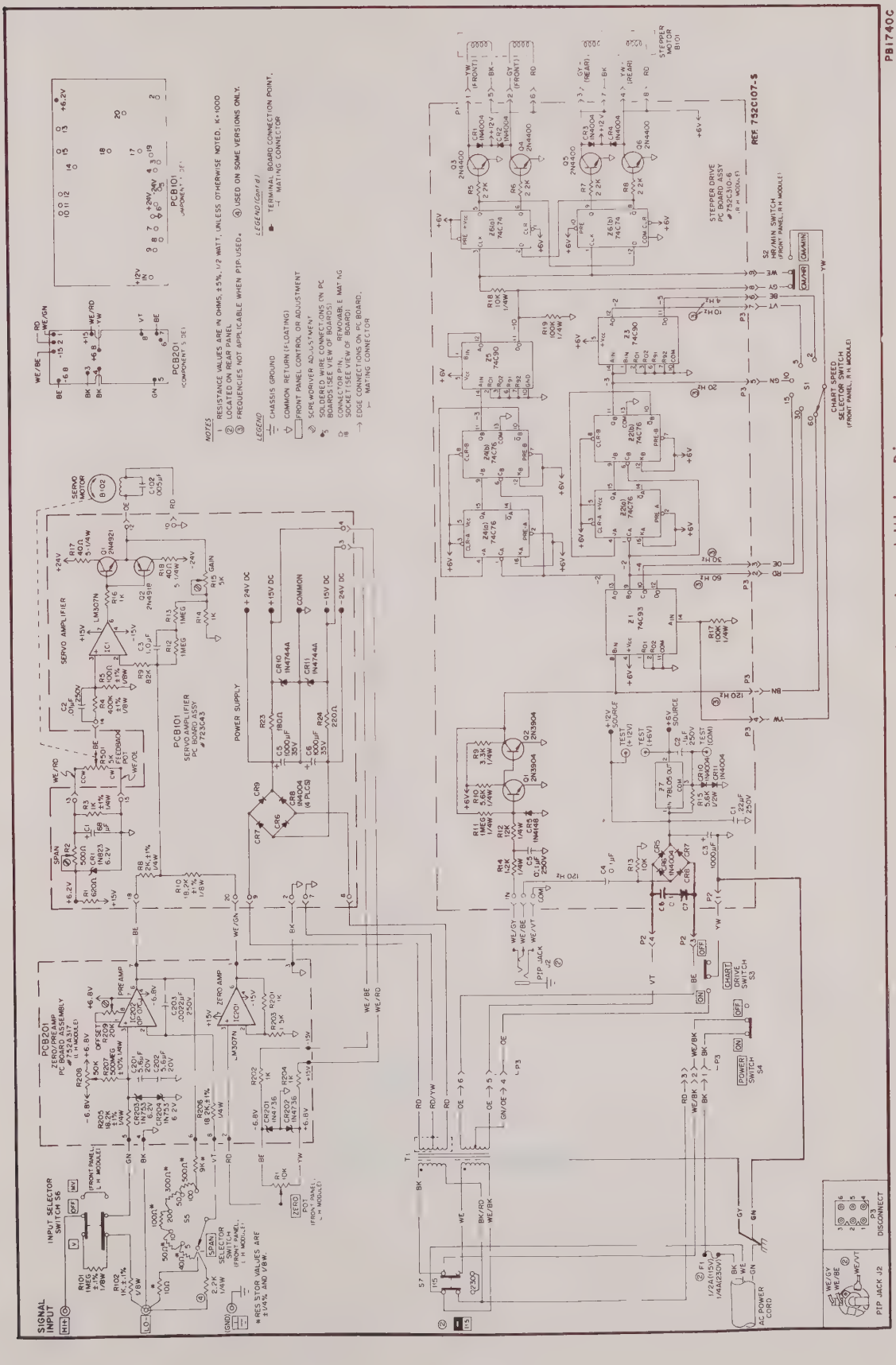


Figure 4-4. Composite Schematic and Wiring Diagram.

SECTION 5 - PARTS LIST

5.1 INTRODUCTION

This section of the instruction manual includes complete listings of all replaceable parts for the AC operated Miniservo Recorder. Each parts list table covers a major assembly or group of related components used in the construction of the instrument (see Index below). When options or special features are supplied, refer to the separate supplements and/or drawings furnished with this manual for additional parts listings.

5.2 PARTS TABLES

5.2.1 "PART NUMBER" COLUMN

Esterline Angus part numbers for all replaceable items appear in the "Part Number" column of each parts table. If a number is omitted from this column, the part is an optional component selectable when ordering the recorder. Replacement part numbers for such selectable items will be found on the instrument Data Sheet furnished with this manual.

5.2.2 "DESCRIPTION" COLUMN

All parts are identified by either an electrical or mechanical nomenclature in the "Description" column of each parts table. This column employs an indention system so that the user can determine the precise parts included in each assembly. Any assembly that is comprised of field replaceable parts will have those parts indented directly below the assembly listing.

5.2.3 "QUANTITY" COLUMN

The number represented in the "Quantity" column of each parts table refers to the quantity used in the assembly covered under the title of each particular list. This quantity, therefore, *does not* necessarily reflect the total number used in the entire instrument. More than one Qty. column will exist when differences between major assembly options cause variation in the number of parts required. The term "A/R" in a quantity column listing is an abbreviation for *As Required.* This term is used generally on optional parts.

5.3 ORDERING INFORMATION

All parts and recording supplies are available through Esterline Angus Sales Offices. To ensure prompt delivery and receipt of parts that are compatible with your specific instrument, always mention the recorder Model Number and Serial Number--as well as the part number and description of all items requested.

PARTS LIST INDEX

Table Title	Table No.
Instrument Main Assembly Replacement Parts List	5-1
Chassis Assembly Replacement Parts List	5-2
Servo Amplifier PC Board Assembly Replacement Parts List	5-3
Preamp Module Assembly Replacement Parts List	5-4
Preamp PC Board Assembly Replacement Parts List	5-5
Stepper Drive PC Board Assembly Replacement Parts List	5-6
Chart Drive Module Assembly Replacement Parts List	5-7

Table 5-1. Instrument Main Assembly Replacement Parts List.

Fig. 5-1 Item No.	Part Number	Description	Qty.
	752D20	MS411B AC Miniservo Recorder	1
1	752C547	.Cover Assembly (Complete w/Handle)	1
1A	752C686	..Cover (Blue)	1
1B	752B710-2	..Trim Strip, Cover (Miniservo)	1
1C	723A64	..Handle, Cover (Includes Hardware)	1
1D	752A685	..Support, Rear Panel	1
2	752D695	.Base Pan	1
3	752B759	.Bracket, Logo Mounting	1
4	BUS-1	.Strain Relief	1
5	723A81	.Retainer, Chart	1
6	712A6	.Power Cord	1
7	752B536-1	.Power Transformer Assembly Complete	1
8	752B416	..Transformer (Less captive nuts)	1
9	KPC-21F	..Terminal, Connector	3
10	43207-7	..Connector, Plastic 6 Pin	1
11	43208-2	..Pin, Connector for Item No. 10	6
12	752C107-1	.Chart Drive Module Assembly	1
13	752B521	.Drawer, Chart	1
14	752C117	.Preamp Module Assembly	1
15	723C43	.Servo Board Assembly	1
16	57534	.Switch, 115/230V	1
17	723B50	.Baffle, Chart	1
18	752A628	.Logo, Esterline Angus (5-1/4")	1
19	723A76	.Wedge	3
20	-	Item Number Not Used.	-
21	752C17-5	.Chassis Assembly	1
22	-	Item Number Not Used.	-
23	723A73	.Loading Chute	1
24	723A77	.Standoff	2
25	752A630	.Spacer, Mica	2
26	-	Item Number Not Used.	-
27	723A54	.Foot, Rubber	4
28	14358	.Holder, Fuse	1
29	723A53-2	.Decal	1
30	723B35	.Clip, Scale Mounting	2
31	723B51	.Retainer, Chart	1
32	723A55-1B	.Scaleplate (Standard)	1
33	752B540	.Connector, Rear Panel PIP (Complete)	1
34	723A53-1	.Decal	1
35	14355	.Cap, Plastic Protective	1
36	752B726	.Cover, Panel Hole	1
	723A68-2*	Accessory Kit (Complete)	1
	752A538	Fuse Kit (Includes 2 Fuses and Instruction Sheet)	1
	723A141	50 Hz Pulley Kit (Optional)	1 A/R
	MS752D20	Manual, Instruction	1
	FAG2-.5	Fuse, 115V @ 1/2 amp.	A/R
	FAG2-.25	Fuse, 230V @ 1/4 amp.	A/R
	723A26-6	Ink Cartridge, Red (6-Pack)	A/R

*Includes: One Ink Cartridge, 723A67 Pointer, 59019-1 Chart, 723A115 Screwdriver, and MPG-11 Phone Plug.

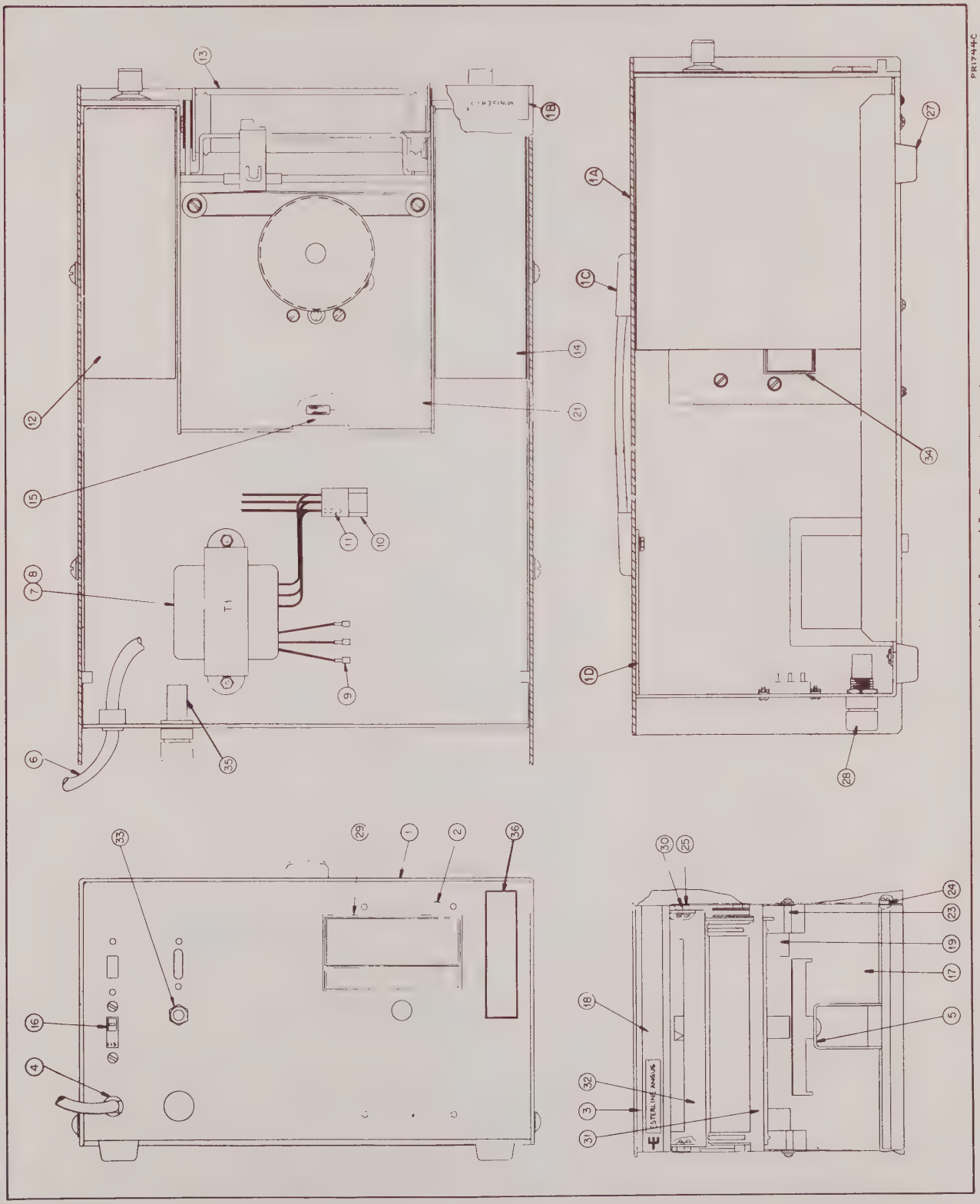


Figure 5-1. Instrument Main Assembly Parts Location.

Table 5-2. Chassis Assembly Replacement Parts List.

Fig. 5-2 Item No.	Part Number	Description	Qty.
-	752D17-5	Chassis Assy., AC , W/Stepper Drive (Complete)	1
1	752B527	.Sideplate Assy. (Right-Hand)	1
2	752B528	.Sideplate Assy. (Left-Hand)	1
3	723B25	.Top Mounting Plate Assy.	1
4	723C10	.Plate, Paper Supply and Guide	1
5	723B24	.Drive Roll Assy. (Transport)	1
6	723A42	.Cartridge Holder Assy.	1
7	723A22	.Rod, Guide	1
8	723A37	.Bail, Pen Lift	1
9	723A32	.Arm, Pen Lift	1
10	SP1906	.Lockwasher (#6)	6
11	723A8	.Pulley, Servo Cable	2
12	723A6	.Spacer, Pulley Mounting	2
13	ND40213-31	.Screw (#5-40 x 5/16")	2
14	ND40213-27	.Screw (#5-40 x 3/16")	2
15	723A16	.Bearing, Pulley	2
16	723A2	.Pulley, Motor (60 Hz)	1 A/R
16	723A3	.Pulley, Motor (50 Hz)	1 A/R
17	723C11	.Bracket, Motor Mounting	1
18	70A199-3	.Belt, Timing	1
19	723A26-6	.Cartridge, Ink (Red) 6/Pack	1
20	723A136	.Washer, Shoulder	2
21	723A135	.Adapter, Motor	1
22	723A40	.Pinion Assembly	1
23	ND40213-34	.Screw (#6-32 x 5/8")	2
24	723A5	.Clamp	2
25	ND40213-38	.Screw (#6-32 x 3/16")	2
26	723B101	.Pulley, Servo Motor	1
27	723B88	.Feedback Potentiometer Assy.; 5k (Complete) R501	1
28	HX38017	.Screw (#6-32 x 1/4")	1
29	NX1106	.Washer (#6)	2
30	723B79P	.Gear, 180-Tooth	1
31	HX38034	.Screw (#8-32 x 3/8")	1
32	43302-1	.Screw (#4 x 3/16) Thd. Forming	6
33	HX38001	.Screw (#4-40 x 3/16")	9
34	NX1004	.Washer, Flat (#4)	2
35	01523	.Cable, Servo Drive	A/R
36	69140	.Bumper, Pulley Stop	1
37	ND40221-4	.Lockwasher (#4)	16
38	723A56	.Washer, Flat	1
39	723A58	.Washer, Spring (Pen Lift)	1
40	ND40213-19	.Screw (#4-40 x 1/4")	2
41	NX30202	.Screw (#2-56 x 1/8")	1
42	NX1002	.Washer, Flat (#2)	2
43	723A57	.Washer, Hat-Type (Pen Lift)	1
44	HX20591	.Setscrew	2
45	43006	."E" Ring, Retaining	1
46	HX30734-3	.Screw (#4-40 x 1/4) Thd. Forming	2
47	HX20593	.Setscrew, Cup-Point (#4-40 x 5/16")	1
48	ND40143-1	."E" Ring, Bowed	1
49	70A137	.Clamp, Pen Lift	1
50	ND40213-69	.Screw (#4-40 x 1/8")	1
51	43302-2	.Screw (#4 x 5/16) PH Thd. Forming	2
52	1HN8-8	.Nut, Hex (#8-32)	1
53	43106-4	.Screw (#8-32 x 3/8") PH	3
54	752B109	.Stepper Motor Assy. W/Connector (Complete)	1
55	723A118-1	.Servo Motor Assembly (Complete) B102	1
56	40763-2	..Capacitor, Ceramic Disc; .005 µF, 1000 V (C103)	1

A/R: As Required

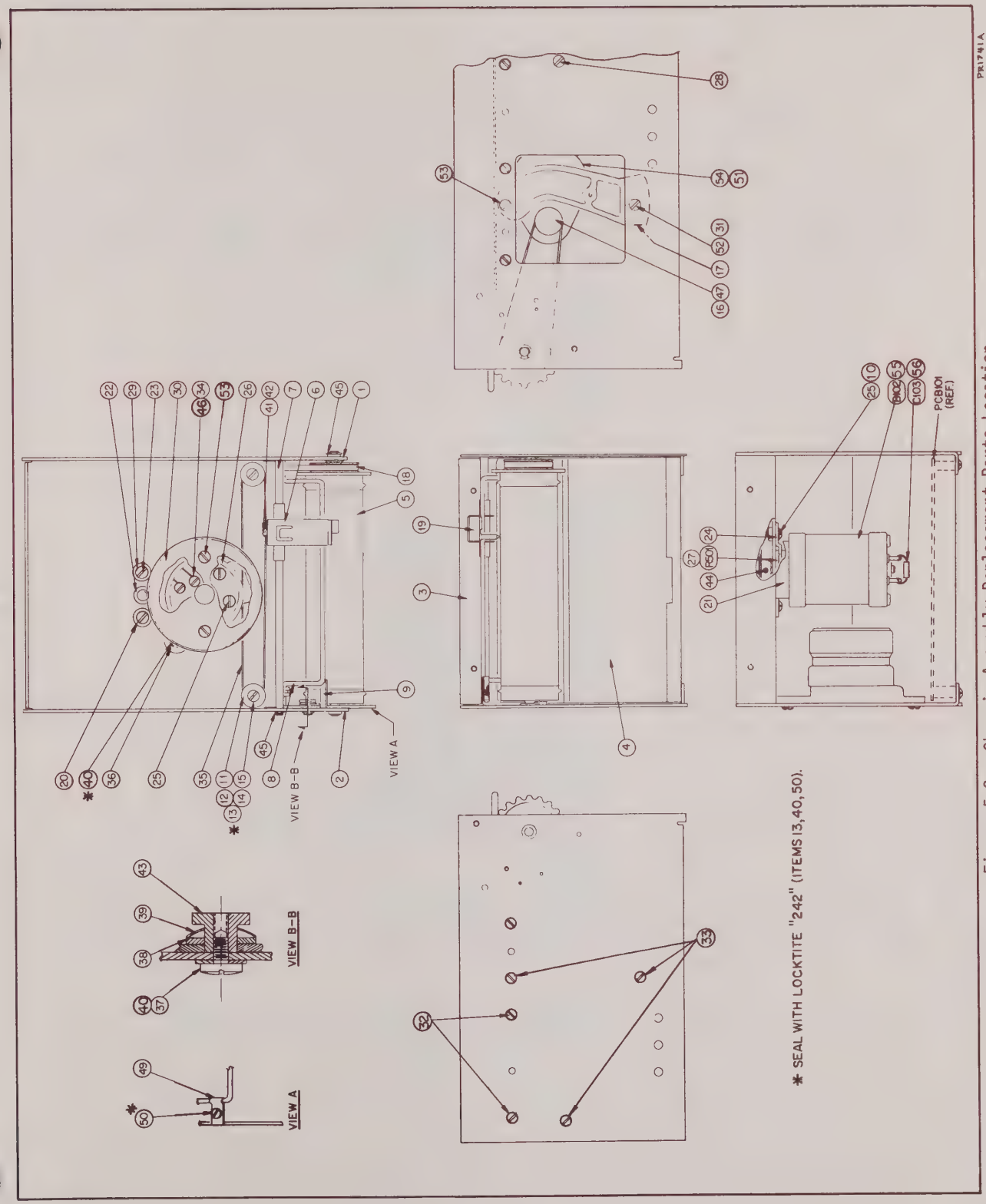


Figure 5-2. Chassis Assembly Replacement Parts Location.

Table 5-3. Servo Amplifier PC Board Assembly Replacement Parts List.

Fig. 5-3 Item No.	Part Number	Description	Qty.
	723C43	Servo Amplifier Assembly	
C1	CEL-134	.Capacitor; 68µF, 6V	1
C2	CMM-41	.Capacitor; 0.01µF, 250V	1
C3	CMM-58	.Capacitor; 1.0µF, 250V	1
C5	CEL-120	.Capacitor; 1000µF, 35V	1
C6	CEL-120	.Capacitor; 1000µF, 35V	1
CR1	43125	.Diode; 1N823	1
CR6	43421	.Diode; 1N4004	1
CR7	43421	.Diode; 1N4004	1
CR8	43421	.Diode; 1N4004	1
CR9	43421	.Diode; 1N4004	1
CR10	67A15	.Diode; 1N4744	1
CR11	67A15	.Diode; 1N4744	1
IC1	OPA-307N	.IC; LM307N	1
Q1	67A13	.Transistor; 2N4921	1
Q2	67A14	.Transistor; 2N4918	1
R1	RCC-1-621	.Resistor; 620Ω, 5%, ½W	1
R2	PPC-25	.Potentiometer; 500Ω	1
R3	RMF-4-10000	.Resistor; 1KΩ, 1%, ¼W	1
R4	40760-21	.Resistor; 400KΩ, 1%, ¼W	1
R5	40760-5	.Resistor; 100KΩ, 1%, ¼W	1
R8	RMF-4-20000	.Resistor; 2KΩ, 1%, ¼W	1
R9	RCC-1-823	.Resistor; 82KΩ, 5%, ¼W	1
R10	52123-31	.Resistor; 18.2KΩ, 1%, ¼W	1
R12	RCC-1-105	.Resistor; 1 MegΩ, 5%, ¼W	1
R13	RCC-1-105	.Resistor; 1 MegΩ, 5%, ¼W	1
R14	RCC-1-102	.Resistor; 1KΩ, 5%, ¼W	1
R15	PPC-26	.Potentiometer; 5KΩ	1
R16	RCC-1-102	.Resistor; 1KΩ, 5%, ¼W	1
R17	RWW-30-400	.Resistor; 40Ω, Wirewound, 5W	1
R18	RWW-30-400	.Resistor; 40Ω, Wirewound, 5W	1
R23	RCC-1-181	.Resistor; 180Ω, 5%, ¼W	1
R24	RCC-1-221	.Resistor; 220Ω, 5%, ¼W	1
1	723B20-C	.PC Board	1
2	723A46	.Standoff	4
3	KPC-21M	.Terminal, Connector	20
4	70A178	.Heat Sink	1

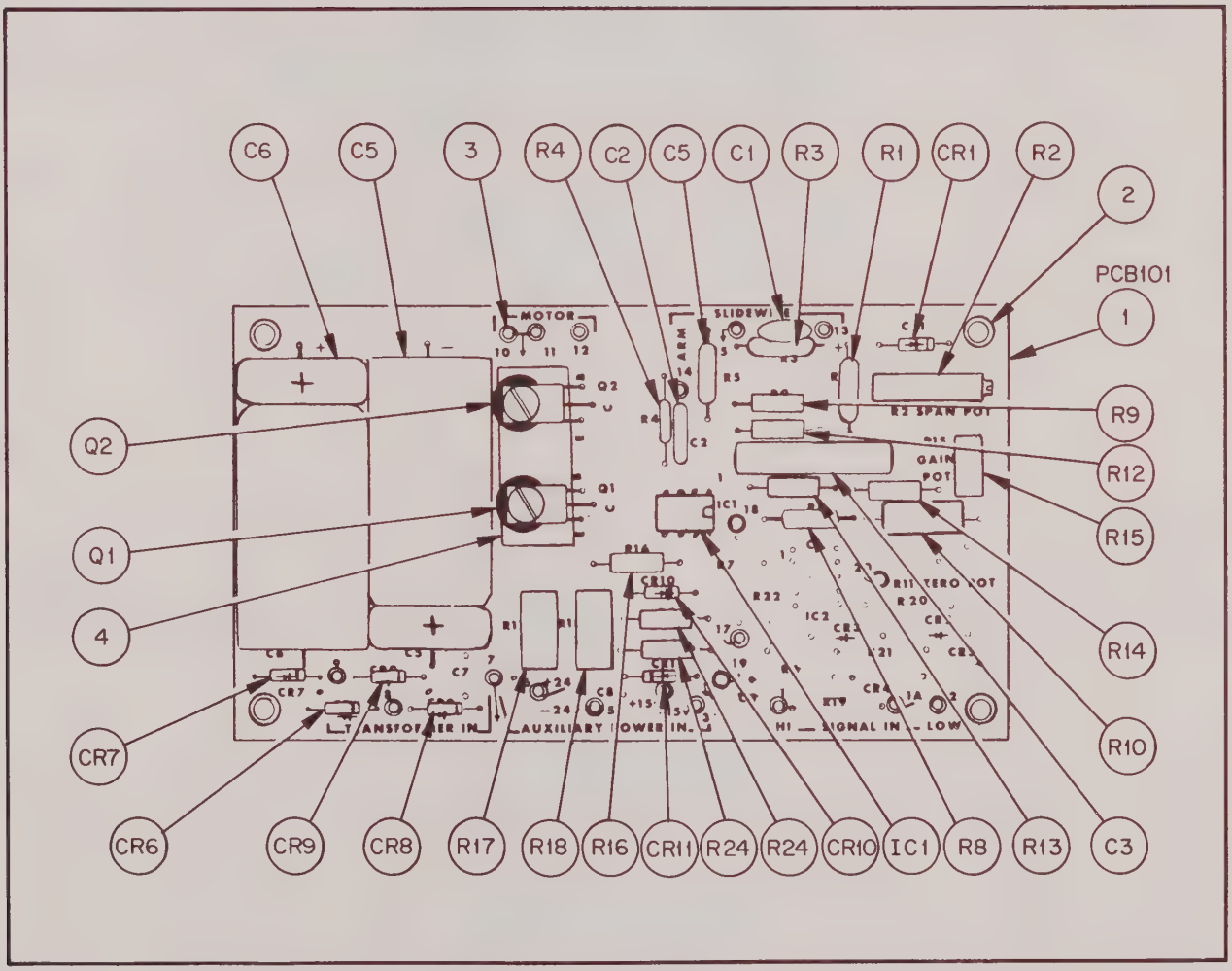


Figure 5-3. Servo Amplifier PC Board Assembly Replacement Parts Location.

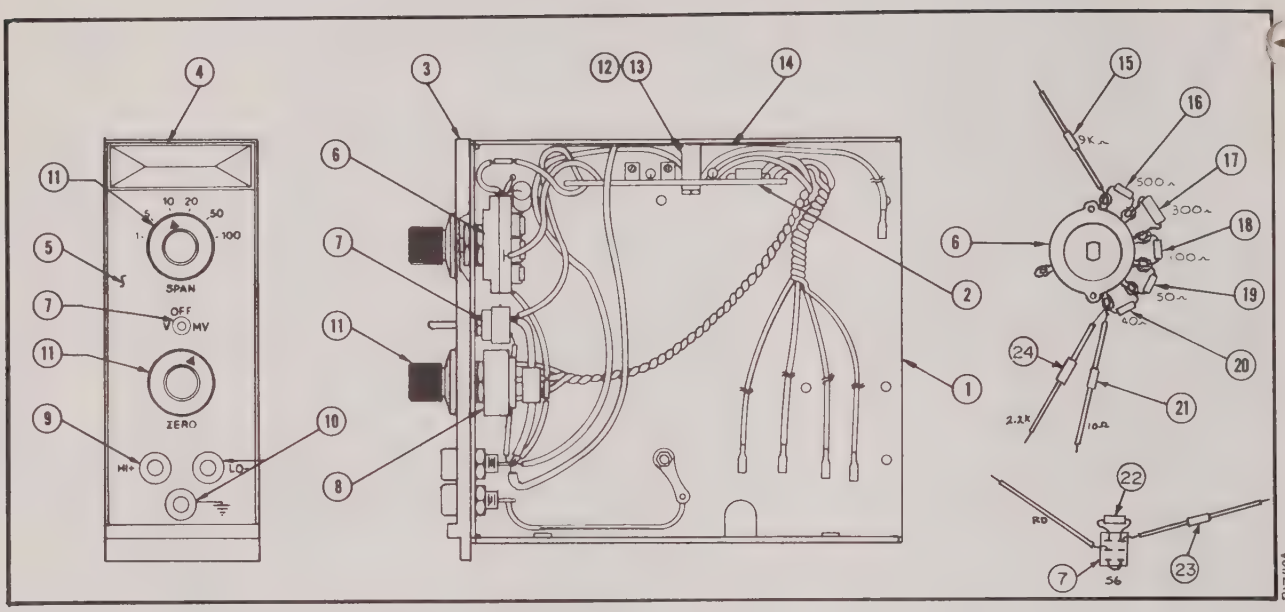


Figure 5-4. Preamp Module Assembly Replacement Parts Location.

Table 5-4. Preamp Module Assembly Replacement Parts List.

Fig. 5-4 Item No.	Part Number	Description	Qty.
	752C117	Multi-Range Preamp Module Assembly	1
1	752C698	.Box, Preamp	1
2	752A317	.Preamp PC Board Assembly	1
3	752B699	.Bezel, Plastic	1
4	752B672	.Cover, Plastic	1
5	752B691	.Escutcheon, Preamp	1
6	752A412	.Switch, Rotary	1
7	SWT1-20	.Switch, 3 Position Toggle (S6)	1
8	752A413	.Potentiometer, 10KΩ (ZERO)	1
9	JAC11	.Jack, Red	1
10	JAC12	.Jack, Black	2
11	723A63	.Knob, (Zero and Span)	2
12	752A711	.Washer, Nylon	2
13	752A712	.Spacer, Nylon	2
14	752A718	.Shield, Analog	1
15	RMF32-90000	.Resistor; 9KΩ, 1/8W, ¼%	1
16	RMF32-50008	.Resistor; 500Ω, 1/8W, ¼%	1
17	RMF32-30008	.Resistor; 300Ω, 1/8W, ¼%	1
18	RMF32-10008	.Resistor; 100Ω, 1/8W, ¼%	1
19	RMF32-50009	.Resistor; 50Ω, 1/8W, ¼%	1
20	RMF32-40009	.Resistor; 40Ω, 1/8W, ¼%	1
21	RMF32-10009	.Resistor; 10Ω, 1/8W, ¼%	1
22	RMF9-10003	.Resistor; 1Meg , 1/8W, ±.1%	1
23	40724-16	.Resistor; 1001Ω, 1/8W,±.1%	1
24	RCC10-222	.Resistor; 2.2KΩ, 1/4W,±5% (some versions only)	1

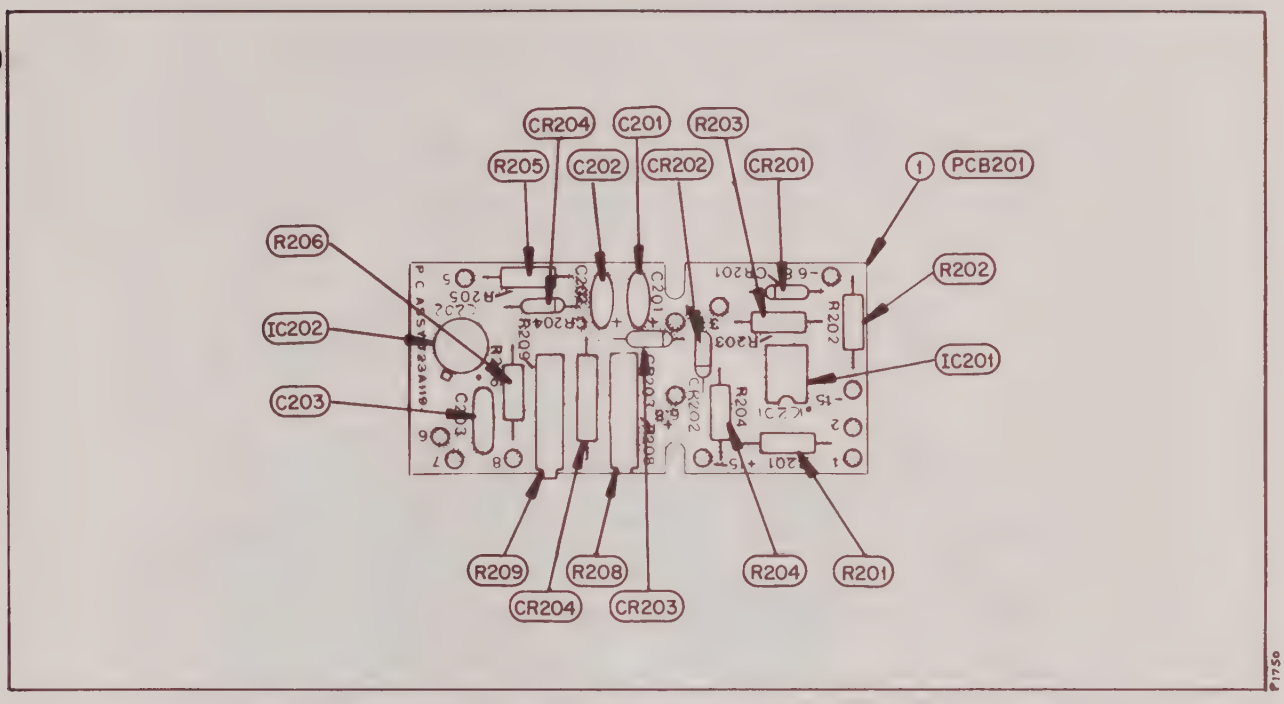


Figure 5-5. Preamp PC Board Assembly Parts Location.

Table 5-5. Preamp PC Board Assembly Replacement Parts List.

Fig. 5-5 Item No.	Part Number	Description	Qty.
PCB201	752A317	Preamp PC Board Assembly, Complete	1
C201	CEL-80	Capacitor; 5.6µF, 20V	1
C202	CEL-80	Capacitor; 5.6µF, 20V	1
C203	CMM-47	Capacitor; .0022µF, 250V	1
CR201	52147-4	Diode; Zener, 6.8V, 1N4736	1
CR202	52147-4	Diode; Zener, 6.8V, 1N4736	1
CR203	DIZ753	Diode; Zener, 6.2V, 1N753	1
CR204	DIZ753	Diode; Zener, 6.2V, 1N753	1
IC201	OPA307N	Op-Amp; LM307N	1
IC202	OPA-07CP	Op-Amp; OP-07CJ	1
R201	RCC-1-102	Resistor; 1KΩ, 5%, ½W	1
R202	RCC-1-102	Resistor; 1KΩ, 5%, ½W	1
R203	RCC-1-152	Resistor; 1.5KΩ, 5%, ½W	1
R204	RCC-1-102	Resistor; 1KΩ, 5%, ½W	1
R205	52123-31	Resistor; 18.2KΩ, 1%, ¼W	1
R206	52123-31	Resistor; 18.2KΩ, 1%, ¼W	1
R207	RMF36-50005	Resistor; 500 MegΩ, 10%, ¼W	1
R208	PPC-10	Potentiometer; 50KΩ	1
R209	PPC-9	Potentiometer; 20KΩ	1
1	723A119-1	PC Board Only	1

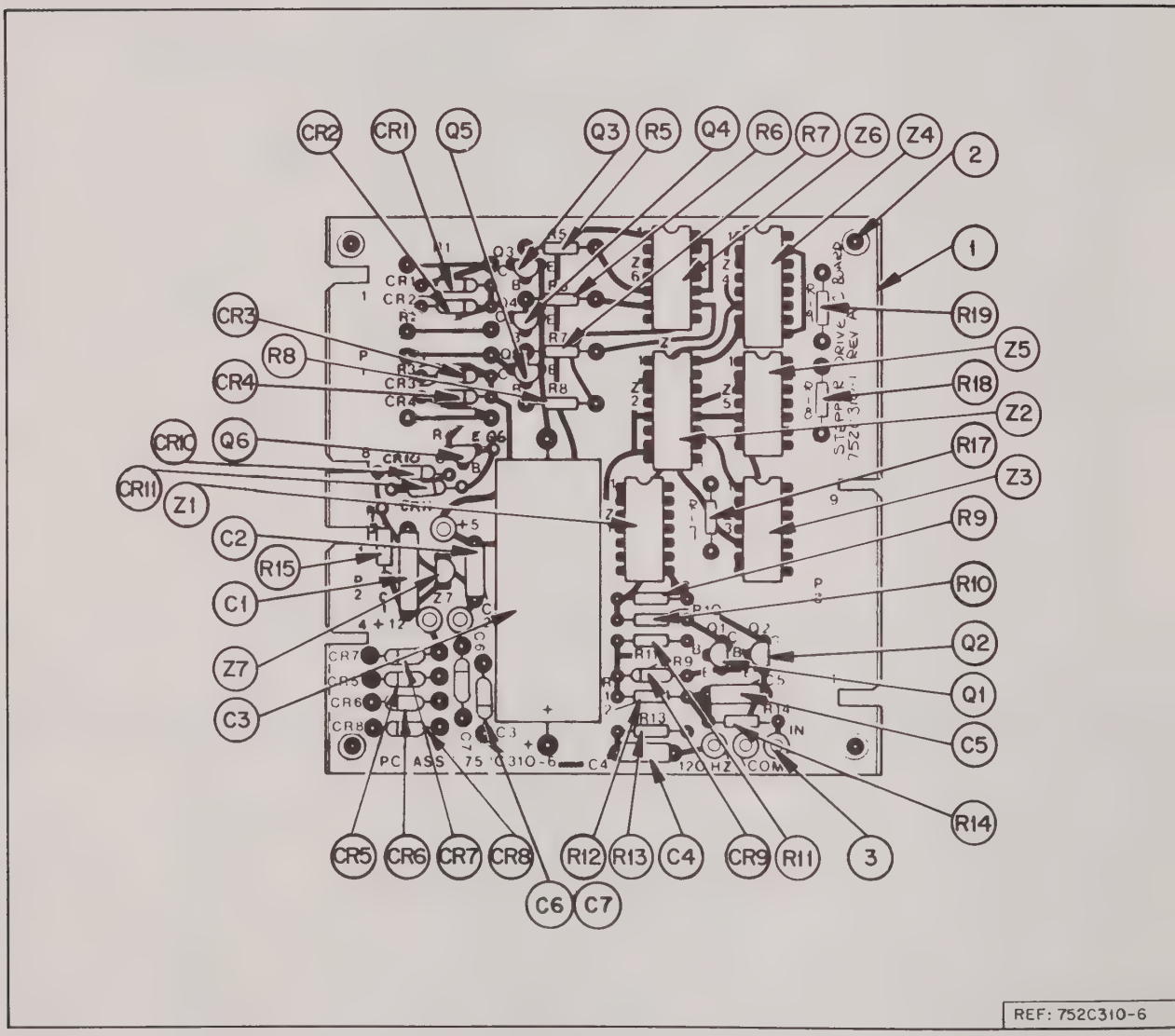


Figure 5-6. Stepper Drive PC Board Assembly Replacement Parts Location.

Table 5-6. Stepper Drive PC Board Assembly Replacement Parts List.

Fig. 5-6 Item No.	Part Number	Description	Qty.
	752C310-6	Stepper Drive PC Board Assembly, Complete	1
C1	CMM-52	.Capacitor; 0.22µF, 250V	1
C2	CMM-39	.Capacitor; 0.1µF, 250V	1
C3	CEL-120	.Capacitor; 1000µF, 35V	1
C4	CMM-39	.Capacitor; 0.1µF, 250V	1
C5	CCR-2	.Capacitor; 0.1µF, 50V	1
C6	CCR-2	.Capacitor; 0.1µF, 50V	1
C7	CCR-2	.Capacitor; 0.1µF, 50V	1
CR1	43421	.Diode; 1N4004	1
CR2	43421	.Diode; 1N4004	1
CR3	43421	.Diode; 1N4004	1
CR4	43421	.Diode; 1N4004	1
CR5	43421	.Diode; 1N4004	1
CR6	43421	.Diode; 1N4004	1
CR7	43421	.Diode; 1N4004	1
CR8	43421	.Diode; 1N4004	1
CR9	43421	.Diode; 1N4004	1
CR10	43421	.Diode; 1N4004	1
CR11	43421	.Diode; 1N4004	1
Q1	TRA3904	.Transistor; 2N3904	1
Q2	TRA3904	.Transistor; 2N3904	1
Q3	45362	.Transistor; 2N4400	1
Q4	45362	.Transistor; 2N4400	1
Q5	45362	.Transistor; 2N4400	1
Q6	45362	.Transistor; 2N4400	1
R5	RCC10-222	.Resistor; 2.2KΩ, 5%, 1/4W	1
R6	RCC10-222	.Resistor; 2.2KΩ, 5%, 1/4W	1
R7	RCC10-222	.Resistor; 2.2KΩ, 5%, 1/4W	1
R8	RCC10-222	.Resistor; 2.2KΩ, 5%, 1/4W	1
R9	RCC10-332	.Resistor; 3.3KΩ, 5%, 1/4W	1
R10	RCC10-562	.Resistor; 5.6KΩ, 5%, 1/4W	1
R11	RCC10-105	.Resistor; 1 MegΩ, 5%, 1/4W	1
R12	RCC10-123	.Resistor; 12KΩ, 5%, 1/4W	1
R13	RCC10-103	.Resistor; 10KΩ, 5%, 1/4W	1
R14	RCC10-122	.Resistor; 1.2KΩ, 5%, 1/4W	1
R15	RCC10-562	.Resistor; 5.6KΩ, 5%, 1/4W	1
R17	RCC-10-104	.Resistor; 100KΩ, 5%, 1/4W	1
R18	RCC-10-103	.Resistor; 10KΩ, 5%, 1/4W	1
R19	RCC-10-104	.Resistor; 100KΩ, 5%, 1/4W	1
Z1	MOS-74C93	.IC; 74C93	1
Z2	MOS-74C76	.IC; 74C76	1
Z3	MOS-74C90	.IC; 74C90	1
Z4	MOS-74C76	.IC; 74C76	1
Z5	MOS-74C90	.IC; 74C90	1
Z6	MOS-74C74	.IC; 74C74	1
Z7	ICT-78L05	.IC; Regulator, 78L05	1
1	752C310-1	.Stepper Drive PC Board Only	1
2	723A46	.Standoff	4
3	KPC-21M	.Terminal, Connectors	6

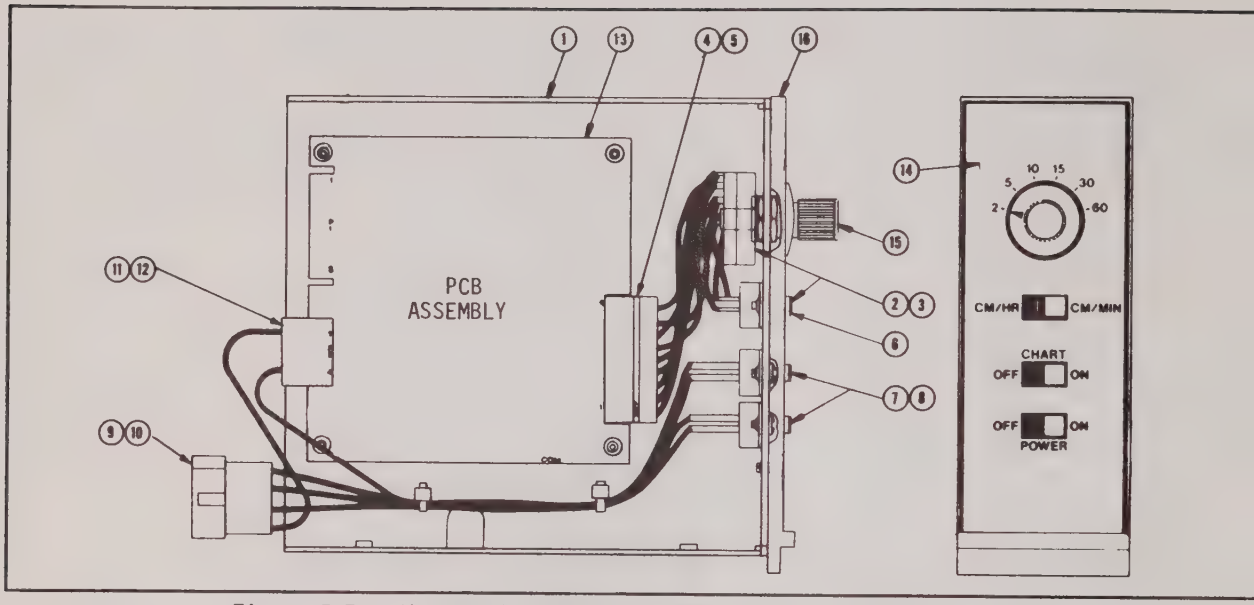


Figure 5-7. Chart Drive Module Assembly Replacement Parts Location.

Table 5-7. Chart Drive Module Assembly Replacement Parts List.

Fig.5-7 Item No.	Part Number	Description	Qty.
	752C107-1	Chart Drive Module Assembly, Complete	1
1	752C696	.Box, Chart Drive	1
2	752B525	.Switch, Rotary-Speed Select, Complete	1
3	752A412	..Switch, Rotary	1
4	KPC-34	..Connector, Plastic 9-Pin	1
5	KPC-35	..Terminals for Item No. 4	9
6	51166	..Switch, Slide-Min/Hr.	1
7	752B535	.Switch, Power Assembly Complete	1
8	51166	..Switch, Slide-Chart off/on, Power off/on	2
9	43207-4	..Connector	1
10	43208-2	..Terminals, for Item No. 9	4
11	KPC44	..Connector	1
12	KPC35	..Terminals, for Item No. 11	2
13	752C310-6	.Stepper Drive PC Board Assembly	1
14	752B689	.Escutcheon	1
15	723A63	.Knob	1
16	752B699	.Bezel, Plastic	1

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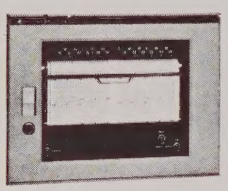
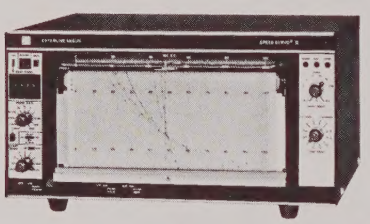
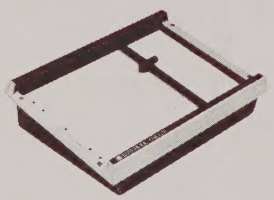


Direct writing recorders: Widest range of direct writing instruments—from 4½" single channel curvilinear to four 2⅜" channel Rectigraph recorders. Electrodynamometer or permanent magnet moving coil types. To record (generally) mA, A, V, W, Vars, KVA, frequency, pressure, vacuum, speed, position. Electric or spring drives with hr., min., and sec. chart speeds. **Event recorders too.**

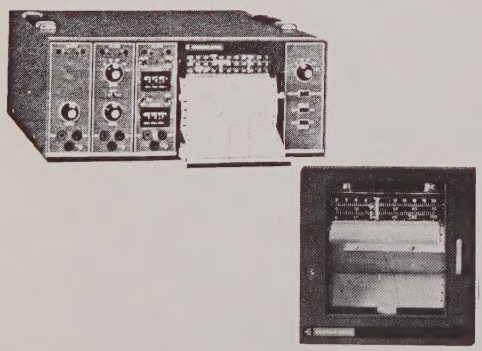


Speed Servo® II recorders: Single pen, two-pen crossover, two-pen side-by-side. 0.3 sec. response, 10" recorder. All feature linear servo motor, wireless feedback potentiometer, and 2, 5, or 10 chart-speed drives.

Ink or inkless multipoint: Inkless multipoint recorder thermally brands analog data on up to 24 channels at 1 second print rate on 10" heat-sensitive chart. Universal input panel accepts millivolt/volt or thermocouple inputs. Alarms. Bench, rack mount or panel mount styles.



X-Y recorders for every need: Model 530 is for general lab use, with a sensitivity of 1 mV/in to 10 V/in. Model 540 is a two-pen crossover ideal for analytical readout, plotting dependent vs. independent voltages, or statistical plotting. Model 575 is stripped down for OEM applications, or order with add-on multirange module. Slew speed 45 ips both axes. Pen drop repeat rate of 45 cycles/sec.



Miniservo® III recorders for lab or industry: 1, 2 or 3 pens per servo recorder with independent amplifier per channel. Lab model features flexible building block concept with a selection of five interchangeable plug-in amplifiers from 1MVDC, AZAS and four chart drives. Bench case, 10 cm chart width. Industrial Miniservo III has built-in transmitter loop power supply ideal for process industry. Seismic approved. 7" x 7" panel mounted.

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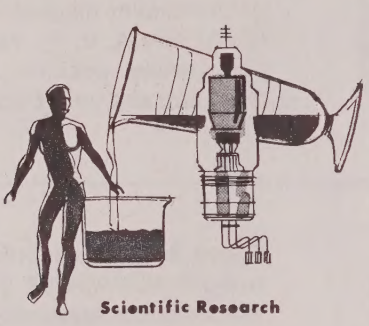
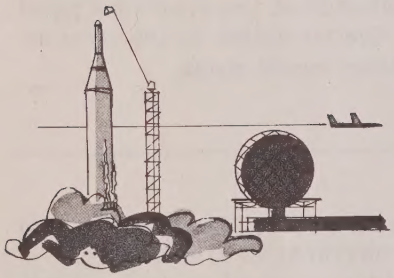


Scientific Research



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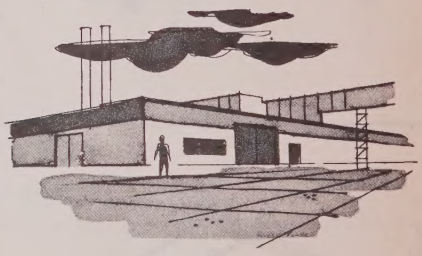

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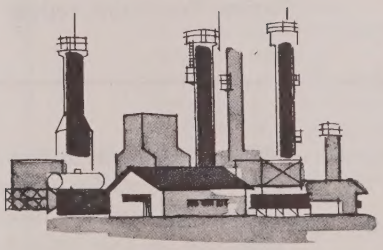

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